DEPARTMENT OF THE INTERIOR
BUREAU OF EDUCATION

BULLETIN, 1920, No. 42

EDUCATION FOR HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT

REPORT OF THE CONFERENCE ON HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT EDUCATION, HELD IN WASHINGTON, MAY 14 AND 15, 1920, UNDER THE DIRECTION OF THE COMMISSIONER OF EDUCATION

WITH

REPORTS OF THE PRELIMINARY MEETINGS

Prepared under the direction of
F. L. BISHOP and WALTON C. JOHN

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

CONTENTS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, September 21, 1920.

SIR: On May 14-15 I held in Washington a Conference on Education for Highway Engineering and Highway Transport. This was attended by about 75 highway engineers, deans and supervisors of engineering in colleges, universities, and technical schools, National, State, and county highway commissioners, and men interested in highway and automotive transportation. Out of this conference there grew a committee which will continue the consideration of this subject until the desired results in more adequate preparation for these phases of education have been obtained. The proceedings of the conference have been edited for publication as a bulletin of the Bureau of Education. I am herewith transmitting the manuscript.

This bulletin contains much material of immediate and practical value to those who are directly interested in the problems of education for highway engineering and highway transport. I am, therefore, asking that it be printed as early as possible.

Respectfully submitted.

P. P. CLAXTON,
Commissioner.

The SECRETARY OF THE INTERIOR.

EDUCATION FOR HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT.

INTRODUCTION.

Preliminary investigations made by the Bureau of Education, with the cooperation of the Bureau of Public Roads, the National Automobile Chamber of Commerce, the State highway departments, and other agencies national in scope, have revealed the necessity of a relatively large number of college-trained men able to cope with the many problems of highway and highway transportation engineering.

In order to determine more accurately these needs the Commissioner of Education called a meeting of a committee on January 28, 1920, in the Bureau of Education. The committee, in addition to Commissioner Claxton, included the following: Mr. T. Warren Allen, general inspector, Bureau of Public Roads; Mr. A. T. Goldbeck, engineer of tests, Bureau of Public Roads; Mr. Charles R. Mann, chairman, Advisory Board, War Plans Division, War Department; Dr. Samuel P. Capen, and Dr. Walton C. John, Bureau of Education.

The committee studied in a general way the nature of some of the problems facing the colleges of engineering; first, with respect to the improvement of highway engineering curricula; second, with respect to the number of college-trained highway engineers probably required in the near future; third, with respect to increased research in highway construction problems.

It was recommended that further inquiry should be made into the problems presented, on account of the lack of data.

Almost at the same time the leaders in the automotive and tire industries became aware of a need of a large number of college-trained men to further the many interests of highway transportation. Consequently, representatives of highway transport interests were called into conference on February 13, 1920, by Mr. Roy D. Chapin, president of the Hudson Motor Car Co. The conference group included Mr. R. C. Hargreaves, vice president of the National Highway Traffic Association, and district manager of the Goodrich Tire & Rubber Co., of Detroit, who acted as chairman of the meeting; Mr. Pyke Johnson, secretary of the highways committee of the National Automobile Chamber of Commerce, Washington, D. C.; Mr. C. W. Reid, chief of the transportation bureau of the Federal Highway Council, Washington, D. C.; Mr. E. T. Herbig, secretary and treasurer of the National Association of Motor Truck Sales

Managers, Wabash Ind.; Mr. C. S. Pike, Paige Motor Co., Detroit, Mich.; O. T. Hillschafer, Chandler Motor Car Co., Cleveland, Ohio; Mr. John S. Pearson, representing Dr. Hollis Godfrey, president of Drexel Institute, Philadelphia; and Dr. Walton C. John, of the Bureau of Education.

An attempt was made at this meeting to ascertain in a general way the extent of the demands for auto-truck operators, fleet managers, transportation managers, and transportation salesmen. It was agreed that each one of the interests represented at the meeting should endeavor to define more clearly the problems which were being raised in order that at a future time suitable recommendations might be prepared for the use of colleges and schools of engineering as well as for the industries.

With this in mind a conference was called under the auspices of the National Highway Traffic Association at Ann Arbor, Mich., at the Michigan Union, on April 15, 1920. This meeting was attended by representatives of the automotive and tire industries, the Michigan State Highway Commission, American Association of State Highway Officials, colleges of engineering, and the Bureau of Education.

The following delegates were present:

C. R. Alden, head of the engineering department, Detroit Institute of Technology.

A. H. Blanchard, professor of highway engineering and highway transport, University of Michigan, and president National Highway Traffic Association.

Roy D. Chapin, president Hudson Motor Car Co., Detroit, Mich., vice president National Automobile Chamber of Commerce.

H. R. Cobleigh, National Automobile Chamber of Commerce, New York, N. Y.

Frank Cushman, Federal Board for Vocational Education, Indianapolis, Ind.

F. W. Davis, consulting engineer, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

George C. Diehl, chairman Good Roads Board, American Automobile Association, Buffalo, N. Y.

R. C. Hargreaves, vice president National Highway Traffic Association and district manager Goodrich Rubber Co., Detroit, Mich.

W. K. Hatt, head of the school of civil engineering, Purdue University, Lafayette, Ind.

E. T. Herbig, secretary and treasurer National Association of Motor Truck Sales Managers, Wabash, Ind.

O. T. Hillshafer, Chandler Motor Car Co., Cleveland, Ohio.

Charles S. Howe, president Case School of Applied Science, Cleveland, Ohio.

Walton C. John, United States Bureau of Education, Washington, D. C.

Pyke Johnson, secretary of Highways Committee, National Automobile Chamber of Commerce, New York, N. Y.

George E. Myers, professor of industrial education, University of Michigan, and supervisor of education for State board for vocational education, Ann Arbor, Mich.

Frank F. Rogers, chairman State highway commission, Lansing, Mich.

H. M. Rugg, director of technical instruction, Y. M. C. A. schools, New York, N. Y.

H. G. Shirley, secretary Federal Highway Council, Washington, D. C.

H. E. Riggs, professor of civil engineering, University of Michigan.

CONDENSED REPORT OF THE PRELIMINARY CONFERENCE ON HIGHWAY AND HIGHWAY TRANSPORT ENGINEERING EDUCATION, ANN ARBOR, MICH., APR. 15, 1920.

The preliminary conference on highways and highway transport engineering education was held in the Michigan Union, April 15, 1920.

The temporary chairman, Mr. Roy D. Chapin, called the meeting to order at 11 a. m. Before introducing the chairman of the day, Mr. Chapin called attention to the important changes in the mode of living in this country which have resulted from the use of the motor car. The automobile and motor truck have become vital factors in maintaining our economic equilibrium.

During the latter part of the nineteenth century this country witnessed a great period of railroad construction. However, in recent years relatively little railroad construction has been undertaken, but there has been a great increase in the use of highways for the shorter hauls. The war made it clear that the roads had become very important commercial arteries; and, on account of the increasing demand for highway transport, unusual problems have developed in highway construction and maintenance in addition to those of highway transport.

Among those problems is that of the education of men capable of meeting the issues of the new era of gas.

The automobile industries doubtless employ more trades than any other industry, and each of these must have men who understand the problems connected with auto transportation.

It is the purpose of this meeting to study the means by which colleges and universities can be helped in developing the right courses of study and in obtaining those men which are urgently needed in the development of highways and highway transport in this country.

Mr. Chapin then introduced the chairman of the day, Mr. R. C. Hargreaves, of Detroit.

Mr. Hargreaves emphasized the importance of this new era in transportation. Attention was called to the value of the work done up to the present by highway engineers in building roads for this new type of transport.

Nevertheless, the time has come for the preparation of fundamental data concerning the many phases of highway transport, similar in scope and importance to the notable work by Wellington entitled "The Economic Theory of the Location of Railroads."

Mr. Frank F. Rogers, chairman of the Michigan State Highway Commission,[1] was introduced at this time.

He stated that out of the 250 employees now working for the State highway department about 80 or 90 are graduated civil engineers; the rest are men who have had more or less engineering education, with the exception of the clerical and auditing forces. Mr. Rogers's preference is for college graduates who have been raised on the farm or in a small country village, for men who understand the psychology of the farmer.

It was also brought out that the time had come when there should be a clear understanding between the manufacturers and users of motor vehicles—particularly trucks—that these vehicles should not be built, nor should they be loaded, beyond certain limits, in order that the expense of road building might not reach a prohibitive figure.

The chairman next introduced Mr. George C. Diehl, county engineer, Buffalo, N. Y.

Mr. Diehl discussed the highway engineering and highway transport professions from the standpoint of the American boy. He called attention to the necessity of building the boy's character by means of a work or a profession which will be of utility and service. Such vocations are found in modern highway construction and in those industries which center about auto transportation.

Furthermore, boys and girls should know the value of the highway. The study of the road problems should not be limited to the college, but should be a part of elementary and high school programs.

Students should know the rules of the road and of traffic.

It is also desirable that highway officers of all types should have a far greater acquaintance with the economics of road construction and of traffic regulations.

Mr. H. G. Shirley, secretary of the Federal Highway Council, stated that road builders could put the crust of the road together. They could assemble the materials, they could mix them, and they could spread them for the slab; but up to the present nothing was definitely known of the construction or the contents of the ground on which the slab is to rest. Few superficial tests have been made. Nothing is known concerning the attraction or the gravitation of the soil; nothing about its bearing power.

Not until the problem of the soil is solved will roads be built substantially or economically.

The next on the program was Mr. E. T. Herbig, secretary and treasurer of the National Association of Motor Truck Salesmen, who said, in brief:

[1] Mr. Rogers was also delegated to represent Mr. Paul D. Sargent, president of the American Association of State Highway Officials.

There are 700,000 motor trucks in the country to-day, representing an investment of nearly $2,000,000,000. This does not include upkeep and maintenance, which reach a very much higher figure. Yet it is said that the motor-truck industry is still in its infancy.

Motor-truck fleets are being operated to an increasing extent by individual owners. Mention may be made of the American Railway Express Co., that now operates approximately 2,000 motor trucks. The Armour, Swift, Cudahy, Morris, and Wilson packing companies own and operate very large fleets of motor trucks.

The truck manufacturers are seeking men competent to take over the handling and supervision of these large investments in motor-truck equipment. These men are hard to find.

It should also be borne in mind that to-day the motor-truck manufacturers are not selling merely motor trucks; they are selling transportation—that is, fitting the particularly well-adapted transportation unit to the particular job.

In view of the opportunities opening up for trained motor-truck engineers, transportation experts, etc., special courses, collegiate in character, should be offered for the training of these men. The training of motor-bus and motor-truck drivers deserves special attention in view of the important investments involved.

Mr. F. W. Davis, of the Pierce-Arrow Co., followed and spoke of his effort to train men to take charge of motor-truck fleets. In preparing for his lectures he found a great deal of information available but in poorly organized form. There was, indeed, a great need of a handbook on highway transport, just as the chairman had remarked.

The Society of Automotive Engineers has planned to gather data concerning the rudiments of the science of transport engineering.

THE AFTERNOON SESSION.

After adjournment for lunch the afternoon session was called to order by Chairman Hargreaves at 2 p. m. Mr. Chapin at this time spoke of the greatly increased use of the passenger automobile. This adds materially to the problems now under discussion. Nevertheless, education for the automotive industries goes far beyond that of training skilled engineers or mechanics. It means the preparation of men for such varied services as are found in advertising, service, and executive departments. The educational problem is indeed a general one.

President C. S. Howe, of Case School of Applied Science, was next introduced.

His viewpoint was that of the college executive. He agreed with the speaker who had said "We did not know very much about highway construction"; he would go further and say "We don't know

anything about it." When the best road an engineer can build is put down and goes all to pieces in one season, and the bottom also drops out, it is evident the engineer did not know the principles of highway construction.

A special study of the highway should be made, preferably by a Government organization with adequate authority and plenty of money. This organization should experiment with all kinds of soils and all kinds of roads.

As to the colleges, they are very desirous of helping in the solution of these problems, but they are limited in many ways and especially in the matter of money. A large number of college faculty members are leaving because manufacturers offer higher salaries than the colleges can pay. If the colleges are to expand and give the industries the men they want, college faculties must be greatly enlarged, but the increased amounts needed to pay the new professors can not at present be obtained. The situation is also further complicated by the great increase in college enrollments.

As to specialization in engineering, it was felt that there was a danger of overspecialization on account of the demands of the many and varied industries for specialized courses or curricula. The college should not specialize too much. Perhaps the additional special training now needed in highway and highway transport engineering could be successfully carried on in a practical way during the freshman, sophomore, and junior vacation periods. This experience would make the students more useful to the industries immediately after graduation.

It should be borne in mind that most of these students must take up something that will pay them, so that they can lay up money to live on the following year while they continue their college work.

Dr. W. K. Hatt, of Purdue University, was the next speaker. He called attention to the unexpected load under which the engineering schools are staggering. He suggested that the automotive interests should endow chairs in highway transport and should come to the campus as other organizations are doing and recruit students for their own needs, and at the same time there should be established organic cooperative relations in the colleges for reciprocal service in training men for these industries.

In introducing the next speaker, Prof. A. H. Blanchard, of the University of Michigan, Chairman Hargreaves spoke of the leadership of the university in developing comprehensive courses in highway engineering and highway transport and in offering special facilities for study and research to engineers in active service.

Prof. Blanchard, in the opening of his remarks, stated that the men to be trained by the universities for positions in the field of highway engineering fall into three classes: First, the men who

are to enter the highway departments of our States, counties, and municipalities; second, the men who are to be engineers for highway contractors; and, third, the men who are to occupy the positions of sales engineers for companies manufacturing highway machinery and materials. As has already been outlined, the demand for those men far exceeds the supply. How is the demand being met to-day?

Highway engineering in the majority of the institutions throughout the United States is looked upon as a side issue. In many institutions the course in highway engineering consists of descriptions of methods of constructing various types of roads and pavements. Naturally the result has been that only two or possibly three hours per week for a half year of the entire four years have been devoted to this subject, and in the majority of institutions the work has been given by men who have had no training in highway engineering and have no interest in it. Due to the fact that the great majority of institutions only give a two or three hours' course, the presidents, trustees, or boards of regents do not consider it practicable to secure the services of a man who is especially trained in that field.

The situation is complicated in those institutions which feel that more attention should be given to highway engineering, because many able teachers of highway engineering are leaving educational institutions on account of the low salaries paid and the readiness with which they can secure professional or commercial positions in highway work to which is attached satisfactory financial remuneration. If it is desired that highway engineering be taught in the near future by properly trained men, it will be necessary to select institutions well distributed throughout the United States and to create chairs of highway engineering which shall be independent of the financial budgets of the institutions concerned.

Following this Prof. Blanchard outlined various courses in highway engineering and highway transport. In order to avoid duplication the outlines are given on pages 87–91 in connection with the recommendations of the committee on highway transport education at the Washington conference.

By special invitation of the chairman, Prof. H. E. Riggs, of the department of civil engineering of the University of Michigan, gave a historical résumé of the development of highway engineering education at the University of Michigan.

Prior to October, 1912, the work in the department of civil engineering at the University of Michigan did not include any separate course in highway engineering. The only attention devoted to the subject was a small part of the time of a course on general municipal engineering problems.

In the spring of 1912 the department was recognized and the chair of civil engineering was divided, new chairs being created in

structural engineering, sanitary engineering, hydraulic engineering, and highway engineering. This latter chair was not filled at the time that it was created, but new men were called to the university to the other three new full professorships.

A course in highway engineering, two hours a week during the senior year, was inaugurated at this time and was required of all students in civil engineering.

In the fall of 1914 it became evident to the staff that highway engineering was a subject of vital importance in the State of Michigan, and that it would be necessary, in order to meet the demands of the State highway department and the county, to devote more attention to the subject than had been done in the past.

Consequently, Mr. John R. Cox was asked to devote his whole time to the subject of highway engineering. Courses in roads and pavements, design of highway structures, highway laboratory, and highway and municipal surveys were inaugurated in the fall of 1914. During this year it was felt that the work of the highway laboratory could be very greatly extended and its usefulness to the State emphasized if it were placed at the service of the people of the State. A program was formulated and perfected by the board of regents under which the highway laboratory was placed at the disposal of officials throughout the State and all tests of highway materials such as cement, rock, sand and gravel, concrete, asphalt, asphalt mixtures, asphalt block, brick, and culvert pipe were made by the laboratory free of charge. One permanent assistant was placed in the laboratory, and during the year a considerable number of tests were made.

During the next four years the work of the department grew rapidly and interest in the work developed very largely among the students. A most cordial relation has always existed between the departments in the university and the State highway department, the university being unreservedly back of every move which has been made by the State highway commissioner to better conditions and methods in all parts of the State.

With the resignation of Mr. Cox to accept the county engineership of Washtenaw roads in the fall of 1919, Prof. Arthur H. Blanchard was appointed professor of highway engineering in charge of the university work.

Prof. Blanchard recommended the adoption of the short period mid-winter courses which were perfected by the regents and put into effect in a small way during the year 1919–20. The amount of work in highway engineering was somewhat increased and the courses enriched, so that at the present time it is probable that the Michigan work is unexcelled in any university in the general character of the course that is required of graduates taking this line of activity. At the same time that Prof. Blanchard was appointed, Mr. John H.

Bateman, engineer for the State highway commission, was appointed assistant professor of highway engineering and director of the laboratory. The laboratory work has been systematized and very greatly increased. In the fall of 1919 the laboratory was recognized as the official State laboratory of the State highway department. At the present time the work of the laboratory has grown to such an extent that five assistants are employed, and during the month of June, 1920, the laboratory completed 198 tests for the State highway department, 9 for municipalities of the State, 10 for the University of Michigan, and 1 for the United States Bureau of Public Roads, a total of 218 tests.

In the spring of 1919 Mr. Roy D. Chapin, president of the Hudson Motor Car Co., of Detroit, an alumnus of the university, urged on the civil engineering staff and on the authorities of the university the importance of devoting some attention to the subject of highway transportation and the relation of the highways and the traffic to take care of it, suggesting that courses in highway economics and highway transport be established. During the past year much attention has been given to this subject. One course was offered and given among the short-period courses, and courses were outlined for regular university work in this subject.

Plans are on foot for a closer correlation of the work of the department of mechanical engineering, under which head the subdepartment of automobile engineering is thoroughly established at Michigan, and the work of civil engineering.

It seems to be clear that the present time, during the period of large expenditures in the building of roads and in view of the greatly increasing interest in that subject, is the time for the colleges to devote their best energies to a thorough study of all phases of the economics and engineering of the subject. The president and board of regents of the University of Michigan have been prompt in their recognition of the timeliness of this work and have been liberal in the extreme in their support of it, in line with their general policy of devoting all available funds to the particular line of work which is of present importance and value to the people of the State.

In this manner the work in highway engineering and highway transport has grown at the University of Michigan from a very small beginning six years ago to the work of importance and magnitude from the educational standpoint and of merit as an adjunct and auxiliary of the State highway department.

From the outset it has been entirely free from politics and free from jealousies. The work is distinct. The university has nothing to do with the building of roads in the State other than in a purely advisory capacity in the matter of passing upon the quality of materials and the general subject of standards of specifications for

materials. The majority of work is clearly the training and preparation of men for service in the field of highway engineering and in the new field of transportation which is developing and will develop in our modern highways.

At the chairman's request a brief summary of the discussions of the committee were made by Dr. Walton C. John, of the Bureau of Education, who called attention also to the fundamental work carried on by Mr. Chapin and Mr. Hargreaves and their associates in Washington at the time of the war.

The results of the national crisis in transportation have led almost directly to this meeting in Ann Arbor and to the proposed conference soon to be held in Washington.

A clear outline of some of the larger problems now before the committee is found in the book entitled "Democracy in Reconstruction."[2] In his chapter on "Motorized highways the basis of a national transport system," Mr. Hargreaves has shown concisely the relation of an adequately planned and managed motor transport system to the economic development of the country in time of peace. He has also pointed out its determining character as an agency in the successful prosecution of war.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

The following resolutions were proposed by the resolutions committee and, on being put to a vote by the chairman, were passed:

Whereas American science and industry have forged a new unit of highway transportation which is destined to bring about far-reaching changes in life and in thought, not only in this country but in the world; and

Whereas as a vital necessity to the economic development of those problems not alone in the economic location, construction, and maintenance of our highways, but in the preparation of skilled men to undertake both the administration and operation of these highways and of the industries devoted to the production of these units of transportation, and

Whereas the American people have seen fit to meet the need for better highways with appropriations for hundreds of millions of dollars for roadbeds which can only be expended efficiently and intelligently as we comprehend in the fullest extent the relationship existing between the highway and highway transportation, while industry has created giant organizations to supply the transportation units; and

Whereas these problems, calling as they do for men of the highest collegiate and vocational preparation, can best be solved through the development of collegiate and vocational education in highway engineering and highway transportation: Now, therefore, be it

Resolved, That we, the representatives of education, industry, and Government, assembled in conference at Ann Arbor to discuss the problems before us, do call upon the Hon. P. P. Claxton, Commissioner of Education of the United States, to bring this subject to the attention of the people of the United States

[2] "Democracy in Reconstruction," edited by Frederick A. Cleveland and Joseph Schafer. 1919.

through a conference to be held in Washington and consisting of the leaders in thought and in action on this subject; and be it further

Resolved, That in order to assist and advise with the United States Commissioner of Education in any manner which he may deem fitting, the chairman of this conference is directed to name a committee of three members, representing education, industry, and Government.

The chairman accordingly appointed the following gentlemen: Dr. Walton C. John, of the Bureau of Education; Mr. Thos. H. MacDonald, Chief of the Bureau of Public Roads, United States Department of Agriculture; and Mr. Pyke Johnson, secretary of the highways committee, National Automobile Chamber of Commerce.

At this conference the question of a four-year curriculum in highway transport and cognate subjects will be carefully studied. We may be assured that the results of the investigations of this conference, both in behalf of highway-transport education and highway engineering education, will be studied carefully by engineering educators at large.

19843°--21——2

PROCEEDINGS OF THE CONFERENCE ON HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT EDUCATION, HELD IN WASHINGTON, D. C., MAY 14 AND 15, 1920.

PROGRAM OF THE CONFERENCE.

Chairman: P. P. Claxton, United States Commissioner of Education.

Executive secretary: Walton C. John, specialist in charge of land-grant college statistics, Bureau of Education.

Educational secretary: F. L. Bishop, dean of the school of engineering, University of Pittsburgh, secretary of the Society for the Promotion of Engineering Education.

FRIDAY, MAY 14, FORENOON SESSION.

10.00 a. m.

(a) Address of welcome by the chairman, P. P. Claxton, Commissioner of Education.

(b) "The Widening Field for Engineers in Highway Development," by Thomas H. MacDonald, Chief of the Bureau of Public Roads, United States Department of Agriculture.

(c) "The Need for Better Trained Men in Highway Engineering and Highway Transport Engineering," by Roy D. Chapin, president of the Hudson Motor Car Co.

(d) "What Attitude should Technical Schools take toward the Demand for Training in a New Professional Specialty," by Samuel P. Capen, director of the American Council on Education.

(e) "The Curricula in Highway Engineering and Transportation," by Walton C. John, specialist in charge of land-grant college statistics, United States Bureau of Education.

12.30 p. m. RECESS.

AFTERNOON SESSION.

GROUP MEETINGS.

2.15 p m.

(a) *Conference committee on highway engineering education.*

Chairman: Thomas H. MacDonald, Chief of the Bureau of Public Roads.

Educational subcommittee: Secretary, W. K. Hatt, head of the school of civil engineering, Purdue University; Hector J. Hughes, professor of civil engineering, Harvard University; C. J. Tilden, professor of engineering mechanics, Yale University.

(b) *Conference committee on highway transportation education.*

Chairman: George C. Diehl, chairman good roads board, American Automobile Association.

2.15 p. m.—Continued.

Educational subcommittee: Secretary, A. H. Blanchard, professor of highway engineering and highway transport, University of Michigan; Emory R. Johnson, dean, Wharton School of Finance and Commerce, University of Pennsylvania; John Weber, associate professor of mechanical engineering, University of Pittsburgh.

(c) *Conference committee on business education and highway and technical research.*

Chairman: Dr. A. F. Woods, president of the State University of Maryland.

Educational subcommittee: Secretary, George F. Zook, specialist in higher education, United States Bureau of Education; A. T. Goldbeck, engineer of tests, Bureau of Public Roads; Charles S. Howe, president Case School of Applied Science, Cleveland, Ohio.

3.45 p. m.

Resolutions committee.

Chairman, Roy D. Chapin, president Hudson Motor Car Co.; secretary, Pyke Johnson, secretary highways committee, National Automobile Chamber of Commerce.

7.30 p. m. BANQUET.

Mr. Roy D. Chapin, presiding.

Guests of honor.

Hon. John Barton Payne, Secretary of the Interior.
Hon. Charles E. Townsend, United States Senator from Michigan.

SATURDAY, MAY 15; FORENOON SESSION.

10.00 a. m.

General meeting.

(a) Reading of the reports and resolutions of the educational subcommittees.

(b) Report of the committee on resolutions.

(c) Appointment of the permanent committee.

(d) General discussion.

12.45 p. m.

Adjournment.

LIST OF THOSE WHO ATTENDED THE CONFERENCE ON HIGHWAY AND HIGHWAY TRANSPORTATION ENGINEERING EDUCATION.

Representatives of Schools of Engineering, etc.

1. A. H. Blanchard, professor of highway engineering and highway transport, University of Michigan, Ann Arbor, Mich., and president National Highway Traffic Association.
2. W. K. Hatt, head of the school of civil engineering, Purdue University, Lafayette, Ind.
3. Emory R. Johnson, dean of the Wharton School of Finance and Commerce, University of Pennsylvania, Philadelphia, Pa.

4. Hector J. Hughes, professor of highway engineering, Harvard Engineering School, Harvard University, Cambridge, Mass.
5. C. J. Tilden, professor of engineering mechanics, Sheffield Scientific School, Yale University, New Haven, Conn.
6. C. E. Ferris, dean of the school of engineering, University of Tennessee, Knoxville, Tenn.
7. T. R. Taliaferro, dean of the school of engineering, State University of Maryland, College Park, Md.
8. R. H. P. Begg, professor of civil engineering, Virginia Polytechnic Institute, Blacksburg, Va.
9. John Weber, associate professor of mechanical engineering, school of engineering, University of Pittsburgh, Pittsburgh, Pa.
10. John R. Lapham, assistant professor civil engineering, college of engineering, George Washington University, Washington, D. C.
11. S. S. Steinberg, assistant professor of civil engineering, school of engineering, State University of Maryland, College Park, Md.
12. Harold D. Hatfield, director of the school of applied science, Howard University, Washington, D. C.
13. A. J. Scullen, department of civil engineering, Catholic University of America, Washington, D. C.

State and County Highway Officers.

1. Paul D. Sargent, chief highway engineer of Maine, and president of American Association of State Highway Officials, Augusta, Me.
2. George H. Diehl, county engineer, Buffalo, N. Y., chairman of the Good Roads Board, A. A. A.
3. W. W. Mack, Delaware Highway Department, Dover, Del.
4. G. P. Coleman, State highway commission, Richmond, Va.

Executive and Managerial Representatives of the Automotive and Tire Industries.

1. Roy D. Chapin, president Hudson Motor Car Co., Detroit, Mich., and vice president of the National Automobile Chamber of Commerce.
2. H. S. Firestone, president Firestone Tire and Rubber Co., Akron, Ohio, representing Rubber Association of America.
3. M. L. Heminway, manager Motor and Accessory Manufacturers' Association, New York, N. Y.
4. E. T. Herbig, National Assoc. of Motor Truck Sales Managers, Wabash, Ind.
5. F. W. Davis, consulting engineer, Pierce-Arrow Motor Car Co., Buffalo, N. Y.
6. W. V. Logan, manager of pneumatic truck tire sales, United States Tire Co., New York, N. Y.
7. R. E. Macduff, Packard Motor Car Co., Washington, D. C.
8. C. S. Pike, Paige Motor Co., Detroit, Mich.
9. C. M. McCreery, Goodyear Tire and Rubber Co., Akron, Ohio.
10. Raymond Beck, Goodrich Tire and Rubber Co., Akron, Ohio.
11. David Thomas, general manager Motor Truck Manufacturers' Association, 33 West Forty-second Street, New York, N. Y.
12. Ernest Farr, director Ship by Truck Bureau, Akron, Ohio.
13. F. G. Whipple, Service Motor Truck Co., Wabash, Ind.
14. A. O. Horrocks, Goodyear Tire and Rubber Co., Akron, Ohio.

Representatives of Automobile and Transportation Associations.

1. Pyke Johnson, secretary highways committee, National Automobile Chamber of Commerce, Washington, D. C.
2. H. R. Cobleigh, secretary Service Division, National Automobile Chamber of Commerce, New York City.
3. M. O. Eldridge, director of roads, American Automobile Association, Washington, D. C.
4. S. M. Williams, president Federal Highway Council, Washington, D. C.
5. H. G. Shirley, secretary Federal Highway Council, Washington, D. C.
6. C. W. Reid, manager transportation bureau, Federal Highway Council, Washington, D. C.

Representatives of Private Firms and of the Automobile Press.

1. A. N. Johnson, consulting highway engineer, Portland Cement Association, Chicago, Ill.
2. Prevost Hubbard, chemical engineer, Asphalt Association, New York, N. Y.
3. Clyde Jennings, managing editor Automotive Industries, New York, N. Y.
4. Paul Wooton, representative of Engineering News Record of New York, N. Y., 610 Colorado Building, Washington, D. C.
5. George A. Ricker, representative Portland Cement Association, Union Trust Building, Washington, D. C.
6. J. F. Witt, care of Witt, Nagle & Rollins Co., Dallas, Tex.

Representatives of Higher Institutions.

1. S. P. Capen, director of the American Council on Education, Washington, D. C.
2. A. F. Woods, president of State University of Maryland, College Park, Md.
3. Charles S. Howe, president of Case School of Applied Science, Cleveland, Ohio,
4. H. M. Rugg, director of technical instruction, Y. M. C. A. schools, New York, N. Y.

Representatives of the Federal Government.

War Department.

1. C. R. Mann, chairman, Advisory Board, War Plans Division, War Department, Washington, D. C.
2. Lieut. Col. J. M. Ritchie, Motor Transport Corps, United States Army, War Department.
3. Capt. R. A. Osmun, Motor Transport Corps, United States Army, War Department, Washington, D. C.
4. E. R. Jackson, Ordnance Department, United States Army, War Department, Washington, D. C.

Council of National Defense.

5. L. L. Robinson, Council of National Defense, Washington, D. C.

Federal Board for Vocational Education.

6. Capt. Frederick O. Smith, Federal Board for Vocational Education, Washington, D. C.
7. Roy Dimmitt, Federal Board for Vocational Education, Atlanta, Ga.

Department of Agriculture.

1. Thomas H. MacDonald, Chief of the Bureau of Public Roads, Department of Agriculture, Washington, D. C.
2. T. Warren Allen, general inspector, Bureau of Public Roads, Department of Agriculture, Washington, D. C.
3. P. St. John Wilson, chief engineer, Bureau of Public Roads, Washington, D. C.
4. E. J. James, assistant chief engineer, Bureau of Public Roads, Washington, D. C.
5. L. J. Hewes, inspector of public roads, Portland, Oreg.
6. A. T. Goldbeck, engineer of tests, Bureau of Public Roads, Washington, D. C.

Department of the Interior.

1. P. P. Claxton, United States Commissioner of Education, Bureau of Education, Washington, D. C.
2. W. T. Bawden, assistant to the Commissioner, specialist in vocational education, Bureau of Education, Washington, D. C.
3. George F. Zook, specialist in higher education, Bureau of Education, Washington, D. C.
4. Chester D. Jarvis, specialist in agricultural education, Bureau of Education, Washington, D. C.
5. Walton C. John, specialist in charge of land-grant college statistics, Bureau of Education, Washington, D. C.
6. John C. Hoyt, assistant chief, water resources branch, Geological Survey, Washington, D. C.
7. Alex Summers, United States Bureau of Education.

Special guests.

1. Hon. John Barton Payne, Secretary of the Interior, Washington, D. C.
2. Hon. Charles E. Townsend, Senator from Michigan, United States Senate, Washington, D. C.
3. Judge J. H. Lowe, N. O. T. R. Association, Kansas City, Mo.
4. A. G. Batchelder, executive chairman, American Automobile Association, Washington, D. C.

THE COMMISSIONER'S ADDRESS OF WELCOME.

GENTLEMEN: This conference has been called at the request of the committee on resolutions of the preliminary conference on highway and highway transport education, held under the auspices of the National Highway Traffic Association at Ann Arbor, Mich., April 15, 1920.

I heartily welcome this large delegation this morning and at the same time I desire to express for the Secretary of the Interior his pleasure in having you meet here to confer on a question which is of great interest to him. He regrets that he can not attend the morning session, but he expects to be present this evening.

This conference is significant because there are brought together at one time the representatives of the various agencies concerned with highway construction and highway transport. Other modes of transportation are also represented at this gathering.

The United States has just entered a new era of highway building, which, if properly encouraged and rightfully managed, will be of the greatest importance in developing the manifold resources of the country. The demand for more and better highways is to a large degree caused by the fact that growing business and agricultural interests are determined to have the best and, in the long run, the cheapest means of transporting goods as well as persons.

States, counties, and townships, for years and decades in the "slough of despond," are awakening, both as the result of their own initiative and because of Federal encouragement to see that the good and permanent highway is one of the first essentials of a sound and progressive policy of economic development.

It has been found that a tax for a well-prepared highway is less of a burden than the age-long and discouraging mud tax which has been one of the greatest drawbacks in rural development everywhere.

The rapidly increasing use of the automobile and the autotruck is an important index of both business and social development. Perhaps the most serious educational question facing the country is that of the rural school. Successful rural education, as exemplified in the modern consolidated school, can not be conducted with a real measure of success unless from each school there radiate from 30 to 50 miles of good roads, over which autobuses rapidly course their way with their loads of children and youth, back and forward from school and home.

The betterment of our roads means the widening of the radius of travel. Those who have been suffering the effects of isolation will receive the vision and education which increased travel and intercommunication always have given.

The more we study our civilization, the more we find it dependent upon the development of transportation in its different forms, and in no small degree upon highway transportation.

The growing demand for well-trained men to carry out scientifically the great highway program ahead of us and for men able to properly develop our highway transport facilities has created a double opportunity for our colleges to serve the country in a most helpful manner by educating broadly and thoroughly the men necessary to do the work.

The conference is charged, therefore, with the responsibility of determining and stating as clearly as possible the needs and the qualifications for trained men. The conference will also assist the college by giving such information as may prove helpful in making the necessary readjustments in the courses of study, and in furthering research in the problems of highways and highway transport.

INTRODUCTORY REMARKS OF F. L. BISHOP

DEAN OF THE SCHOOL OF ENGINEERING, UNIVERSITY OF PITTSBURGH.

The object of this conference is to present clearly to the public, and primarily to the engineering schools, the economic and engineering problems involved in the training of a larger number of highway and transport engineers and some suggestions to the faculties of our engineering schools in regard to the development of courses for the training of these men, such courses to emphasize not only the engineering features, but the economics of highway transport.

The personnel of the conference is such as to command the attention of those interested in the development of our highways and illustrates the modern method of solving educational problems, namely, to bring together the men who are to use the young men trained in our colleges with those to whom is intrusted their education. This results in a clear statement of the type of training required, and at the same time the educator can state the limits which of necessity must always be placed on the training.

Traffic in new countries always follows the waterways. When the pioneers begin to branch from these lines of portage, then begins the development of the highways. There is no more fascinating and interesting subject in the history of civilization than the development and use of highways. The framers of the Constitution of the United

States recognized that transportation and communication were of primary and fundamental importance, if the Union which they were creating was to continue, and made provision for the building of highways known as post roads.

Up to the time of the advent of the railroads there was in this country a notable development of the highways and there still remain some of these, such as the post road connecting Boston and New York, the National Pike from Baltimore to the Ohio River, the Philadelphia-Pittsburgh Pike, etc. Over these highways there flowed from the east over the Allegheny Mountains an enormous amount of traffic, and those sections of the country which were reached by these highways were naturally the earliest to develop.

Railroads were looked upon as substitutes for these highways and for several generations the country lost interest in the development of a national highway system, but the advent of the automobile provided a new means of transportation for passengers and freight, and there immediately arose an insistent demand for better roads. This demand has been constantly increasing and reached a maximum during the war, when our waterways and railroads were inadequate to transport the enormous volume of freight which was necessary in order that our troops might be maintained upon European soil. This traffic, composed largely of motor trucks, destroyed to a considerable extent our existing highways.

The problem then that lies before us is twofold:

First, the economic question involved in highways. It is to this economic study of highways that I would particularly call your attention. The cost of transportation in different countries in 1902 was as follows:[3]

Cost of transportation.

Countries.	Per ton-mile, in cents.	Wages per day.
China	$0.10	$0.10
Japan	.05	.23
Russia	.022	.34
Italy	.024	.26
Austria	.0225	.50
Germany	.0150	.90
France	.0190	.80
England	.0260	1.04
United States	.0009	2.60

Second, the engineering questions involved in the construction of modern highways.

The ever-increasing size of the automobile trucks, with their growing use in wintertime, requires a type of construction for roads not

[3] Walker, Guy Morrison. "The Measure of Civilisation," p. 110.

heretofore used. In addition is the necessity for reducing grades, eliminating curves, etc. That the funds which are annually appropriated by the National, State, county, and municipal governments may be properly expended, it is necessary that they be expended under proper engineering supervision. The men for this work must be trained in our engineering schools. Some extraordinary effort must be made to graduate a sufficient number of trained highway engineers from our educational institutions to meet this need.

Education always reacts to the needs of the country, and as a result we may look to the engineering schools to modify their courses in the manner suggested by the conference. This will be much easier for the engineering than for the economic phases of the question.

There is an immense number of definite research problems in highway transport quite apart from what are usually considered engineering problems. Most of these problems must be solved by engineers trained in the economics of highway transport.

THE WIDENING FIELD FOR ENGINEERS IN HIGHWAY IMPROVEMENT AND THEIR TRAINING FOR THE FIELD.

By THOMAS H. MACDONALD, Chief of the Bureau of Public Roads, United States Department of Agriculture.

Any critical period in which production, inclusive of the problems of distribution and transportation, becomes the paramount issue, awakens the public to the importance of the engineer's work, and directs its attention to the necessity for a greater supply of men trained in the various phases of the engineering profession. Just now the interest of the public must extend further. It must examine into the condition in which the educational institutions now find themselves, for the purpose of providing proper support, funds, and enlarged facilities. There must be a recognition of the fact that in the past these institutions have exerted profound influence to advance engineering knowledge, and that there is now a demand for a greater number of technically trained men each year than these institutions can possibly prepare. There must be further recognition of the fact that a much closer correlation of the interests of those responsible for the instruction of engineers in the planning of engineering courses and of those who demand and will absorb the services of the men as they leave the institutions is not only desirable but highly necessary. In this connection it is enlightening to follow the development of engineering courses in American colleges and universities. So many of our experiences occur in cycles that such a study may be regarded as forecasting the immediate future of engineering education, and from this viewpoint the history of this development

rightfully lends encouragement and forms a stable foundation for an optimistic spirit in this conference in its consideration of the problem of supplying trained men to fill the demand for the field of highway development.

Undoubtedly some of the conditions which engineering educators are now feeling are the gravest within the period of their connection with educational institutions. True, also, is the lack of a sufficient number of trained men in all of the different branches of the profession and in all of its different grades. Still, these are public questions, and in the past it has always seemed to require grave issues to direct the attention of the American people toward the causes and to stimulate their activity in removing these causes and providing the proper relief. So we may have faith that satisfactory progress will be made in overcoming the adverse conditions which exist to-day, if proper attention is given these matters by those in a position to give the public correct information.

The first technical school—Rensselaer Polytechnic Institute—was founded in 1824. This was the only school of its kind for nearly a quarter of a century, until 1847, when Harvard established the Lawrence Scientific School and Yale the Sheffield Scientific School. The University of Michigan also established the same year a course in civil engineering. Until the Civil War there were no other schools of this character. In 1862, however, Congress enacted the Morrill Land Grant Act providing, through grants of public lands, for the endowment of schools to teach agriculture and the mechanic arts. This act immediately stimulated the establishment of technical schools, and from a total of 4 in 1860 the number increased to 70 by 1872 and to 85 by 1880. There are now 126 institutions providing engineering courses, 46 of which are land-grant colleges operating under the provisions of the Morrill Land Grant Act. In addition to these, there are 43 other institutions that give some engineering instruction.

In the 5 years, 1911 to 1915, it is estimated that 17,000 engineers graduated, an average rate of 3,400 per year. During the previous decade the average number graduated per year was approximately 2,100. The increase in the number of graduates per year during the present period will not be so apparent until the graduation of the classes which are in their freshman year now. Just what this increase will be is extremely difficult to estimate because of the high percentage of students who dropped out of college between their freshman and senior years. Based on past experience of some of the leading engineering schools, this total is estimated at not more than 5,500. It must be remembered that even this number of engineering graduates.

will not be available until 1923, that the number is likely to be much smaller for this year and the two years following, and that these men will be claimed by all phases of engineering and particularly by the industries.

The four general branches of engineering—civil, mechanical, mining, and electrical—have developed a large number of specialized phases, training in which is offered the student at the different colleges. As illustrative of this tendency, instruction is given in the following, as well as many other fields of engineering: Chemical, sanitary, metallurgical, railroad, marine, cement, electro-chemical, textile, automobile, aeronautical, ceramic, highway, agricultural, and engineering administration. One of the best-known schools offers at least 15 specialized courses.

It will be noted that the greater number of these specialized courses have a direct relationship to the industries, and in this fact apparently lies the crux of the present situation as far as the future supply of highway engineers for the public service is concerned.

As was true after the Civil War, so now a great demand has come suddenly for large numbers of technically trained men, and it must be remembered that the high-school graduate is, under the plan of education generally followed, four years distant from his availability to meet the demands. Industry of all classes has been so tremendously stimulated by the demand for increased industrial production and so well supported by increased prices that the possibilities for advancement in the industrial engineering fields offered the young man when choosing his college course are alluring. Every organization is naturally selfish in its desire to secure the best men, and the industries should not be accused of a greater degree of selfishness than other organizations who require men technically trained, but industry has been more alert in offering a tempting field than the public and semipublic organizations, such as the railroads, Federal and State governmental engineering departments, and like organizations.

It seems well within the province of this conference, therefore, which is interested in the relationship of the engineer to the highway program and the supplying of technically trained men to meet the present and increasing demands in this field, to take account of the widening field of opportunity offered the man who intends to follow some engineering profession to plan the proper methods by which a just and sufficient proportion of young men may be constantly drawn into the highway field, and to consider modification of present methods or adoption of new methods to make the engineering student or graduate more quickly useful and more immediately available for responsible positions.

ENLARGEMENT OF HIGHWAY PROGRAM.

It is not necessary to analyze the causes for the enlargement of the highway program. It is sufficient for the purposes of this conference to point out that the present sentiment for highway improvement is founded upon the sure basis of a direct interest in highway improvement on the part of a very considerable percentage of our entire population, and that percentage is rapidly increasing. This has been brought about, as is well known, by the rapid increase in the use of the passenger car and the more recent freight-carrying motor truck. The expenditures for highway improvement are increasing at a remarkable rate, as shown by the following schedule.

Total expenditures for roads, by years, in the United States.

Year.	Total.
1916	$272,634,413
1917	279,915,332
1918	286,698,192
1919 (estimated)	303,670,105
1920 (estimated available for expenditure)	783,000,000

The tremendous increase from the total estimated expenditure in 1919 of approximately 303 millions of dollars to the estimated amount available for the present year of more than 600 millions is in itself indicative of the widening field of opportunity for the technically trained engineer or the young man who is seeking to choose a profession offering wide opportunity. It is, of course, certain that the expenditures this year will fall under the estimated funds available, due to the economic handicaps which have been placed upon production of highways through the lack of railway transportation, material supplies, contractors' organizations, and labor, as well as the developing limitations of credit. This expenditure, because of these handicaps, may equal no more than 50 per cent of the amounts appropriated or authorized by the public; yet, even so, the supply of engineers necessary to carry out this program averages this year, from estimates furnished by the State highway departments of 36 States, 23 per cent less than the State requirements, which, undoubtedly, means that the more local subdivisions, such as counties, towns, and cities, will show a considerably greater per centage of deficiency in the engineering forces reasonably required, because the larger engineering organizations, including the industries, have recruited many men from these sources.

EXTENSION OF ENGINEERING CONTROL OF EXPENDITURES.

While the greatly increased sums for highway improvement are indicative of the greater field for engineers, the increasing importance of the engineer in relation to the highway improvement program is,

perhaps, best illustrated by the progress which has been made recently in bringing highway expenditures under engineering control. The following article shows the rapid progress which is being made in this direction:

Highway expenditures.

Year.	Under control of State highway departments.	Locally but not under State highway departments.	Per cent under highway departments control.
1916	$71,495,551	$198,138,579	27
1917	98,179,332	181,736,000	35
1918	117,285,268	168,812,925	41
1919	[1] 133,670,105	160,000,000	46
1920	[2] 633,000,000	150,000,000	81

[1] Estimated. [2] Estimated available.

If through the economic limitations before noted the expenditures for 1920 are limited to no more than 50 per cent of the funds available through State and Federal sources, and the local expenditures are maintained at the estimated figure, the proportion of funds spent under engineering control will still be more than 60 per cent of the total funds. The tendency of the times to place all expenditures under engineering control is, however, much more correctly shown by the 81 per cent than by any smaller percentage. This tendency is keeping pace with the growth in the demand for improved highways and the financial support for this purpose. The fact of the growth of engineering control is further emphasized by the large mileage of highways built each year, even during the past three years while highway construction has been so seriously curtailed. The estimates for highways of all types built under engineering control are shown in the following schedule:

Total mileages built by State highway departments under engineering control.

Year	Miles.	Total to date	Per cent of total mileage of nation.
1916	16,180	68,937	2.6
1917	11,996	80,933	3.2
1918	11,944	92,877	3.7

There is a total of approximately 214,000 miles of highways on the State systems which have been chosen for improvement under State direction, or approximately 8½ per cent of the total mileage of the Nation. The State systems vary from 1 to 17 per cent of the total mileage of the several States. Perhaps the most indicative

figure as pointing the way to the future importance of the State and Federal departments is shown by the increase in the mileage of highways maintained under engineering control, as shown by the following schedule:

Total miles maintained by State highway departments.

Year.	Mileage.	Per cent of total mileage of nation.
1916	75,311	3.0
1917	181,391	7.3
1918	203,556	8.1

From this evidence it is apparent, then, that the field for engineers in highway improvement is rapidly widening, because of the demands for highway improvement followed by the appropriation of large sums for this purpose, and that the prevailing tendency of the times is to bring the construction and maintenance of highway improvements under engineering jurisdiction. Already some of the State highway departments are planning for the definite assumption of engineering control of roads which are of no more than local importance in the State. In other words, we are progressing rapidly from a highly decentralized control of highways to definitely organized systems of engineering control of all the highways, from the most important to those serving only communities. From this fact follows this question: Whose responsibility shall it be to direct the attention of young men toward this field and induce them to follow highway engineering as a profession when so many other splendid opportunities are open?

SUPPLYING THE DEMAND FOR TRAINED MEN.

Up to the present time little or no attention has been given by the public or semipublic organizations which need large numbers of engineers toward directing young men into their respective fields. Apparently the supply has been equal to the demand, and little concern has been felt. This fact is now changed. The best illustration is the status of railroad engineering, from which students and graduates have turned with decision. It is reported that one well-known special railway engineering course has a total of four students, all foreigners.

But consider the case of the educational institutions which we are calling upon to train engineers. Under war conditions the teaching staffs were badly disorganized. Last year there was a tremendous influx of new students, and the appropriations have in general been far less than the enlarged needs. Salary budgets have not been revised to

meet the competition of industrial engineering organizations, with the consequent loss of very many of the best qualified professors and instructors.

The instructor who, during prewar time, has taught a specialized course in some particular phase of engineering, such as highway engineering, is called upon to go into general teaching or to spread his activities over a far greater number of students than he can possibly give proper attention to. Educational institutions have necessarily given up their building programs in order to hold their teaching staff together while the additional room is so seriously needed. Our institutions are suffering from an unforeseen expansion which they can not capitalize—to provide funds, as in the case of the industries—and a condition has resulted which the public must understand and provide for. That our educational institutions can not be neglected is a fundamental creed with the greater part of our citizenship, but the present conditions must be understood and given the proper publicity. It may be remarked in passing that this general condition is not peculiar to the institutions of higher education, but extends all down through the whole educational system.

It has been noted that inroads have been made upon the supply of engineers by industries, but it should be added that the State highway departments have responded much more quickly than has the Federal Government or the management of the educational institutions or the railroads, to the necessity of increased compensation to the engineers. The Reclassification Commission, which was appointed to make a study of conditions within the Federal Government and make salary recommendations for all Federal employees, has classified the engineering service of the Government into seven divisions, five of professional and two of lower grades. The following schedule shows the comparison of salaries in the Bureau of Public Roads in 1919 as compared with those in various States and those recommended by the Reclassification Commission, grouped under these several divisions.

Comparison of salaries in the Engineering Service.

Rank.	Bureau of Public Roads, both office and field, exclusive of bonus.			Compensation by various States, reclassification basis.			Recommended by Reclassification Commission.		
	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.
Senior	$4,500	$4,500	$4,500	$5,000	$7,150	$10,000			
Engineer	2,500	3,641	4,000	2,820	4,300	5,000	$3,000	$4,140	$5,040
Associate	2,280	2,656	3,240	2,200	4,100	6,000	3,240	3,540	3,840
Assistant	1,560	2,141	3,000	2,100	2,635	3,300	2,460	2,700	3,000
Junior	960	1,537	2,100	900	1,835	3,060	1,800	1,980	2,160
Civil engineer aid	720	860	1,080	800	1,040	2,080	1,200	1,500	1,800
Junior engineer aid	480	767	1,080	480	915	1,500	840	1,020	1,200
Copyist	840	760	1,080	.....	1,200	.....	1,080	1,170	1,260

[1] Massachusetts, Wisconsin, New York, Delaware, Maryland, Michigan, Pennsylvania, California, Texas, Iowa, Illinois, Indiana, New Jersey, Ohio—14 States.

From these it will be noted that in the 14 typical States having well-organized highway departments the salaries are higher than those recommended by the reclassification commission, and very much higher than those now paid by the Bureau of Public Roads. But even this schedule is lower than the recommendations of the American Association of Engineers or the Engineering Council. The recommendations of this association are shown in the following schedule:

Salaries recommended.

Rank.	Minimum.	Maximum.
Senior	$8,000	$15,000
Engineer	4,800	10,000
Associate	3,600	5,000
Assistant	2,400	4,000
Junior	1,800	2,400
Engineer aid draftsman	1,800	2,400
Junior engineer aid	1,200	1,500
Copyist	1,800	2,400

From this evidence it is clear that in order to interest young men in highway engineering and in order to secure and retain the engineering staffs necessary to provide proper training in the educational institutions in this profession, the salaries now paid to engineers must be very materially increased.

As indicating the number of engineers that are now engaged in highway work, there is a total of 312 employed by the Bureau of Public Roads at the Washington headquarters and in the field. Thirty-six States report the following totals:

Number employed by State highway departments	3,939
Number with county highway organizations	1,909
Number with city organizations	1,200
Highway engineers outside of above classes	519

These totals are divided into classes, as follows:

Those above division engineer or similar grade	381
Division engineers or similar grade	903
Resident engineers or similar grade	1,995
Grade below resident engineer	3,952
Unclassified	

It is not presumed that these figures are absolutely correct, but they are indicative of the large number of engineers that are needed in the highway field. The additions which will be required for the next decade are estimated to average from 9 to 12 per cent per year, but it is more than probable that this percentage is far short of the actual percentage that will be required.

RESPONSIBILITY OF ENGINEERING ORGANIZATIONS.

It can hardly be expected that young men in sufficient numbers will enter the field of highway engineering unless they have knowledge of the field ahead, nor is it fair to leave the colleges unaided to develop these men as fast as they will be required. There is a large duty in both these respects which must be assumed by the engineering organizations who wish to use these men. Reference is made particularly to the Federal Bureau of Public Roads, the State highway departments, and similar organizations. Furthermore, our ideals of engineering education were brought into this country from abroad, and the teaching of applied science has in general been founded upon the theory that the student should first learn the theory and later the application. Undoubtedly a canvass of the executive in charge of the highway organizations of to-day will bring out the fact that they have fewer problems of theory and design to meet than of production, organization, and supervision.

It is the duty of these executives to lay before the heads of the educational institutions the necessity for broader training of highway engineers along the lines of the economics of highway engineering as well as in some of the humanities. Every highway department comes closely in contact with the public and has need of men who not only understand the problems underlying the administration of highway organizations and of highway development, but who can present these matters convincingly to the public, without whose favorable support the work of the highway organization can not be successful. The lack of engineers who possess this training has been one of the most serious handicaps to the highway organization.

Fortunately, many highway departments have already played an active part in the development of highway engineering as a profession. To Dean Shaler, of the Lawrence Scientific School of Harvard University, may be credited a very large share in the early teaching and stimulation of real engineering as applied to highway construction and maintenance. The influence of the Massachusetts Highway Commission, of which he was one of the first members, has had a very considerable influence in the development of highway engineering to the position which it occupies to-day. This fact seems indicative of the responsibilities which devolve upon the highway departments of other States in the future. There must be a close coordination and cooperation between the highway organizations and the educational institutions, much closer than has prevailed in the past. As concrete examples of the possibilities for advancement which are inherent in such a relationship are the following suggestions:

First, if the college semesters can be so arranged that students in the various years of the college courses can be placed in appropriate positions for the summer work with the highway organizations. By advancement, from year to year, to positions of greater responsibility, they not only are better prepared to meet the problems which are now paramount with highway executives because of their knowledge of the organization in all of the different classes, but they will more surely connect up their theory with its practical applications. Thus, both the highway departments and the educational institutions will function better in producing capable engineers.

Second, such a relationship will awaken from the start an interest in the student in highway engineering which will prevent his dropping out in his undergraduate years or turning to other courses.

Third, a close contact of the teaching staff with the highway organizations will prove of great mutual benefit.

Fourth, the engineering organizations should assume responsibilities for lectures and other services in the classroom that the students may be constantly brought in connection with the active work.

Fifth, the research work which is of the utmost importance and necessary to every engineering organization, should be closely coupled with the work along similar lines of the educational institutions.

Finally, in the production of highway engineers, there is nothing more valuable than the short courses conducted annually which should be a product of the educational institutions and the highway organizations. It is impossible to cram into four years of a student's life all of the technical information that he will need. It is probable there is too much of an attempt toward this end now, and that the more highly specialized subjects should be left for postgraduate study. The short courses should by all means be developed, and could well be made a part of the year's work for the highway engineering organizations to attend for at least a short period of instruction annually.

These short courses should be of two general classes; first, those for the instruction of graduate engineers for the purpose of keeping them constantly in touch with the rapid developments in the field of highway engineering and for the purpose of preparing them for highly specialized technical work, especially along research lines, and second, those for the instruction along more popular lines for the benefit of public officials or those occupying positions of lesser technical importance in the organization. Practically all highway organizations work through or with public officials who are not technically trained, and who may be impatient of technical limitations and theoretical niceties. The short course along more popular

lines offers the surest way to connect in a harmonious relationship the theoretical and practical minds. The great success which has been attained by many short courses of this latter character has accentuated their importance as a means of bringing highway departments, public officials, contractors, and through them the public in general into closer cooperation, which is the key to the solution of the most difficult problems of highway administration.

THE NEED FOR BETTER TRAINED MEN IN HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT ENGINEERING.

By Roy D. CHAPIN, President of the Hudson Motor Car Co., Detroit, and Vice President of the National Automobile Chamber of Commerce.

No more far-reaching influence has made itself felt in education in modern years than the World War. Hardly had the struggle begun when the importance of training in practical work came to be clearly understood, and at once there was a demand for skilled men such as was beyond anything in our past history.

Now that peace has returned, we find that the colleges of the United States are all engaged in getting their ships into order after the storm. The war demonstrated that courses which had served while the sailing was smooth were not of the greatest efficiency, and to-day there is a movement throughout the land to revise curricula and to shape courses in study so that they will meet with the particular needs of the student who has planned to go into business life.

As one of the great subjects which was developed by the war, and which must be continued in our colleges in the future if the full effects of economic transportation are to be realized, we have highway transportation. Before America's participation the motor truck had been looked upon as a vehicle for use in intracity communication but had not been seriously considered as a unit in transportation. The demands of war changed that viewpoint almost overnight. As the railroads became congested there came an insistent demand for supplementary transportation, and the motor truck answered the call. Hundreds of thousands of men were suddenly drafted into service as motor-truck operators, convoy leaders, and mechanics. Across the seas the arrival of hundreds of motor trucks loaded with soldiers and materials saved the cause of the Allies at Verdun. In this country the motor truck became one of the three great factors in the trinity of transportation over the highways, waterways, and railways. Perhaps the first evidence of this which was seen were long trains of motor-truck convoys traveling from inland ports to Baltimore to handle emergency war supplies which the railroads were unable to take care of. The next step was the sudden coming into life of rural motor express lines. Every ounce of food was needed.

The rural express went from farm to farm, picked up the produce for which the farmer had neither labor nor material to transport, and swelled the volume of food for those on this side as well as on the other.

Intercity fleet lines came into existence. Where in the past years it had been customary for the roads to be used for a radius for some 8 or 9 miles daily, since the horse was limited to that extent, operators driving the motor units of transportation found that they could take thousands of tons of supplies from city to city, with the result that our highways became a network of transportation systems all engaged in supplementing the traffic haulage of the railroads.

The day of fighting is passed, but from this intensive effort has come a permanent addition to the transportation of the country, whether it be freight or passenger in nature. No longer is the motor vehicle looked upon only as an instrument of pleasure. Its place in the economic fabric of the country has become fully understood, and its future is one which must surely have a tremendous far-reaching influence in the lives of the people of the country.

To show how far we have progressed it is only necessary to make a statement that thirty million people ride in automobiles in the United States each day in the year. To some these figures will seem extravagant, but we have practically 8,000,000 motor vehicles in the United States to-day, and we are adding to that number by hundreds of thousands each month. It is not too much to say that each machine carries four passengers a day. To supplement this, we may note that last year 1,000,000,000 tons of freight were hauled by the motor trucks of the country, as against 90,000,000 tons carried on the Great Lakes and the Mississippi and 2,504,000,000 moved by the railroads.

Now, in all of this great, new, transportation development there appears a pressing need for highway transportation engineers, men skilled in production and operation of these transportation units. It is necessary that we should have these men by the thousands if we are to save waste in this great new development and to secure the maximum benefit which we should receive.

In order to handle this subject intelligently it is necessary that it should be coordinated with other forms of transportation, since only through coordination can we hope to obtain the greatest efficiency in the use of each unit. We know that the motor truck is not capable to-day of competing with the railroad in the long haul. We know that under certain limitations it can serve to relieve the railroads. We should have men trained in the analysis of these problems, able to tell us what the definite economic limitations are.

With the increasing use of highway transportation our traffic problems are becoming acute. In the larger cities as well as in the

smaller we find a growing need for definite, well-laid-out plans for the operation of motor vehicles.

There is a further need for the close cooperation between the men who are using the highways and the men who are building them. Their problems in many subjects are mutual. The highway transportation engineer brings to the knowledge of the highway engineer a vision as to the future use of highways. He knows something of the trend of production and of the character and type of vehicles which will travel over the roads of the future.

His knowledge should be of definite value to the highway engineer since, in the last analysis, road expenditure can only be justified by the volume of the traffic which goes over the completed highways. It is not enough to say that we will build a road. We should know what the future traffic will be once that road is completed, and on our vision of the future we should determine the type of highway which is to be built. In other words, I should say that road building is now an economic problem first of all. Location of the highway should be undertaken only with due respect to the tonnage which may be developed along the road or to the character of passenger travel which may go that way.

There are hundreds of millions of dollars available for road building in the United States to-day. The people of the country have shown their belief in the future of highway transportation by the readiness with which they have voted these large sums. Perhaps no other issue before the country meets with the enthusiastic reception which this one does. It is only necessary now that in the future conduct of our highway program we shall seek to avoid any waste and to give to the taxpayer a dollar of value for every dollar expended. The roads which we build must last for the life of the bond voted to cover the cost of their construction. If they do not, then the future would see a reaction against road construction which is unthinkable.

The only way in which this waste can be avoided is through the treatment of this subject as one which requires highly trained men. There must always be waste when the expenditure of money is left in the hands of men who are selected to perform that function by reason of political patronage rather than their trained knowledge.

We must go further. There is an imperative need for the widest kind of research work. I doubt if there is any man in the United States, skilled though he may be, who can define what character of road should be constructed to withstand traffic 10 years from now. The tremendous growth of motor transportation has outstripped our scientific knowledge just as it has outstripped our legal procedure, even administration procedure in our automobile factories in some instances

It is time now that we checked up on the work which we are doing. We should not proceed to spend these hundreds of millions of dollars without knowing in what direction we are going or what results we are to obtain. The colleges and schools should heed this well, as it is the peoples' money which builds the roads, and it is the people who support the schools and colleges and who are vitally interested in both of these subjects. These problems can be solved and our colleges should aid their solution by the institution of broad courses in highway engineering, increased facilities for research, and a broadcast movement to acquaint the public with the high importance of skilled men in this task.

Turning to the transportation phase of my subject, I have intimated that the enormous development in motor transportation has brought about a need for trained men in all of the phases of highway transportation from the department of research and design down to the operator on the road. Glancing over the field it will be found that trained men are lacking. We have not simply had the time as yet to develop them, and we must rely upon our colleges to undertake this task.

It is true in the automobile industry as it is in other industries that, whenever a man is able to perform his duties well, salary becomes a secondary matter from the standpoint of the manufacturer. There is an unlimited field for the ambitious man properly trained who enters the automobile industry.

The subject is a popular one. It takes to itself all the glamour and romance which in another day and another generation led the student to take up the subject of railroad transportation. The boy who goes into the field of highway transportation, whether he goes in as engaged in the production and use of the vehicle or as one engaged in the construction of the road, becomes an intimate part of the life not only of his community but of his State and of the Nation. He is doing more than earning a mere living. He is making it possible for others to obtain more from life, since upon the adequacy of our transportation facilities rests in a large measure the breadth of life of all of us.

The subject is one which is bound to increase in importance. There are 8,000,000 automobiles in use in the United States to-day. Each year sees the number increasing very greatly. Except in Europe the use of the motor vehicle has been largely restricted in other countries. Lack of appreciation, lack of funds, and lack of highways have been responsible. To-day we see a changed condition abroad. More and more automobiles are being demanded from this country. Last year our export shows an increase of 79 per cent. In the years to come we may expect to see broad highways driven

into the heart of old Europe, Asia, and Africa, opening potential resources almost beyond the vision of any of us present. All this means that there will be an ever-increasing field of usefulness, both in the engineering and highway transportation fields.

The subject is one which reaches so closely into the life of the individual that its importance should be impressed upon him at the earliest stage. There is a place for the study in the kindergarten. No child should go through the primary schools without receiving a course in safety first, which will give him a full understanding of the rules of the road whether he live in the city or in the country.

For the student whose education must be limited there should be vocational training which will fit him for work as a skilled mechanic in a factory, as a motor-truck operator or chauffeur in the field, or for any one of the number of other branches afforded by the two subjects under discussion.

When we go to the colleges there should be definite outlines which will equip men for the highest type of employment in these fields. In some cases these courses will be found in the engineering schools, but there will always be a need for a number of men trained in business administration, salesmanship, and advertising who should have more than a vague understanding of the specialized automobile field.

Special degrees should be given in these subjects by our colleges. The reason is not hard to find. Highway engineering is as important a branch of engineering as is any other specialized form, such as railway engineering. Highway transportation will require more men than railroading.

The task ahead is a large one. It is one of sufficient importance to engage the attention of leaders in the two fields in the United States. The national conference on this subject called by Dr. Claxton, Commissioner of Education, is a milestone in educational progress in the United States which the students of the future will look back to as the beginning of a new era in education of most far-reaching importance to themselves and to their children.

WHAT ATTITUDE SHOULD TECHNICAL SCHOOLS TAKE TOWARD THE DEMAND FOR TRAINING IN A NEW PROFESSIONAL SPECIALTY?

By SAMUEL P. CAPEN, Director of the American Council on Education.

One of the striking facts in the social evolution of the last 50 years has been the development of scores of professional specialties. Up to the time of the Civil War there were three commonly recognized professions—theology, law, and medicine. The occupational statistician of to-day has a long professional category. In it most of us would

find callings listed with whose very existence we are unfamiliar. Apparently this process of subdividing the field of expert service is going to continue into an indefinite future.

The future historian of higher education in America will note that, as these professional specialties have developed, schools and colleges have devised courses to train for them. But training always lags behind the professional demand. Engineering, for example, was a well-established calling before engineering curricula were offered by higher institutions. It is within the memory of persons still young that colleges of journalism or of business administration have been founded. Nevertheless, perhaps one of the most extraordinary phenomena in the recent evolution of higher education has been the segmentation of universities into what is now a bewildering number of professional schools and departments.

In the case of engineering, the development to which I have just alluded long ago entered upon a secondary stage. When American universities first offered courses in engineering the term engineering designated a single unified profession. One was trained to be an engineer as one was trained to be a lawyer or a doctor. Indeed, the calling hardly had professional status. The subjects which an engineer was expected to know scarcely furnished the substance of a single curriculum. In a very short time, however, specialties began to split off inside of the profession of engineering itself. This development was reflected in the offerings of engineering colleges. The training offered to prospective engineers was subdivided again and again until the student was no longer a student of engineering, but a student of mechanical engineering, or of production engineering, or of railroad engineering, or of some other engineering specialty.

Now, I believe that certain of the most significant movements in higher education in the last 10 years have had their source in the development that has taken place in the field of engineering training. They have there had their conspicuous testing and application also. The lessons which the student of education has learned from observing the recent tendencies in engineering education must color his whole thinking with respect to the general educational problems of the day. It may, therefore, be worth while to dwell for a moment on these matters. I believe, moreover, that they have a peculiar bearing on the purpose of this conference.

The tendency which I have mentioned, to offer a separate and somewhat highly specialized training to the civil engineer, a different type of training to the chemical engineer, another still to the electrical engineer, and so on, reached its height just before the war. Hardly half a dozen years ago a countertendency began to make itself felt. There was a sharp reaction away from extreme specializa-

tion. Some few engineering schools began gradually to return to a unified fundamental course required of all students. This common course of instruction occupied in some institutions a year, in others two years. Gradually it was extended to cover the larger portion of the four-year course. When I joined the Bureau of Education some six years ago one of the questions that was being hotly debated was, At what point in the course should engineering schools encourage professional specialization?

Many feared the rehabilitation of the old general course, because they believed instruction would then be too theoretical. This danger appears to have been obviated, however, by the various plans that have been worked out in the last few years which enable students to combine from the very beginning their theoretical training with practical experience in engineering undertakings.

The new doctrine received its classic presentation in Dr. Mann's report on engineering education published in 1918. Since then the United States has passed through an experience which has been particularly rich in suggestions to the engineer and to those concerned with the organization of engineering education. If one who is entirely innocent of a professional knowledge of engineering may hazard an opinion, I should say that the stupendous engineering experiences of the war have borne out the propositions set forth in the Mann report. I do not know how far the engineering schools of the country have attempted to recast their work along the lines indicated in that report and indorsed by the special committee of the Society for the Promotion of Engineering Education. I judge, however, that the principles stated therein have for the most part been accepted.

To the lay observer, therefore, it would seem as if we were on the threshold of a new development of engineering schools. The characteristics of this development, if I apprehend it rightly, may be summarized under three heads:

1. It will be the primary task of the engineering schools to teach the fundamental principles of engineering and its basic sciences. Engineering is, after all, not a subject, not a profession, but a method. It is, in a word, the method of science applied in the processes of design, production, and distribution. Indeed it is the fact that it is fundamentally a method, applicable to a large variety of different activities, that accounts for the growth of the numerous engineering specialties that now exist.

2. In the second place, engineering schools will offer at the very end of the regular undergraduate courses or in postgraduate courses opportunities for specialization in one or more of the many branches of engineering.

3. Thirdly, those technical specialties which any individual school will cultivate will be determined in part by its location and in part by its facilities.

In very self-defense the schools must take a course substantially like this. There is no end to the demand for new types of specialized training. For a study which I made in 1915 I counted 14 different kinds of engineering curricula offered by the leading engineering colleges. In the last five years I venture to say that the number has doubled. If my interpretation of the essential character of engineering education is correct, it might easily be doubled again in the next decade. It is clear that no university system will stand the strain of this kind of a demand. Moreover, the experience both of industry and of the persons in charge of essential war operations tends to bear out the contention that the important thing for the schools to give is the general groundwork of engineering training. Particular specialties may for the most part be learned either in post-graduate courses or in actual practice in the field.

Now, if my conclusions are correct they have a very definite bearing on the end and purposes of this conference. The gentlemen who are here assembled have come together to consider what the schools shall do in the face of a large new demand for specialized training. Shall all the engineering schools in the country begin at once to offer courses in highway engineering or in some other phase of highway transportation? Shall this conference outline one or more curricula which are to be urged upon the schools for their adoption?

In my judgment neither of these things should happen. I should regard it as very unfortunate if this conference urged all the engineering schools in the country to offer specialized courses in highway engineering. On the other hand, I am convinced that some institutions should provide special training in those relatively new branches of engineering which we are discussing. This provision should be primarily for advanced students. Being without technical engineering knowledge, as I have before confessed, I should not venture to say at exactly what point in a four-year course it should begin. That is a matter for the schools themselves to determine. The institutions in which organized work of this character should be, I believe, are those situated in the most favorable locations and possessed of appropriate facilities.

I do not minimize the enormous numerical demand for persons with technical training to engage in the construction of highways. A large percentage of those needed for this great national undertaking will not have to have the highest kind of training or professional skill. The institutions which devote themselves to the development of highway engineering and transportation engineering may

appropriately establish extension courses or special courses shorter than the regular engineering curricula for the training of men not of the highest professional grade.

Obviously another large need in connection with this new development is the need for research. This is peculiarly the task of the higher scientific institutions. In short, then, it seems to me probable that a considerable number of engineering schools should undertake the definite exploitation of this large new industry. Their cultivation of the field should include research, the training of a certain number of highly trained specialists, and the training by means of courses not of full professional grade of many men for subordinate positions.

I believe that it would for the present be unwise to encourage more than one institution in a State to devote itself to this field in a comprehensive way. In those States which are fortunate, or unfortunate, enough to possess both a State university and a separate college of agriculture and mechanic arts, only one of these institutions should at the present time commit itself to this task. The decision as to which of the two should undertake it ought to be made by joint agreement.

I should like to make one last point. It is this: I distrust the ready-made curriculum. Dr. Claxton reminded me the other day of a saying of Prof. Rein's. Rein likens a course of study made by one person for the use of somebody else to a wax nose. It looks all right but it doesn't function. The vital thing, as the war experience again has shown us, is a definition of the ends and objects of teaching. Applied to a technical specialty, whether of high or low grade, this means job analysis. The most useful and stimulating document that can be put before persons conducting any kind of vocational or professional training is a definition of the problems and duties which their students will have to meet when called upon to practice the vocations for which they are being trained. You gentlemen who are here assembled can, I believe, make the most useful contribution to the schools if you will define the tasks which the highway engineer and the transportation engineer will have to perform and the particular engineering problems which they will have to solve. The rest may safely be left to the schools.

THE CURRICULA IN HIGHWAY ENGINEERING AND TRANSPORTATION.

By WALTON C. JOHN, Specialist in Charge of Land-Grant College Statistics, Bureau of Education.

Never before has technological education been so important in the life of the Nation as it has been during the last decade. It has taken the war, however, to show the people of the United States that the

well-trained engineer is the man who stands back of nearly every material project of importance that is being conducted on any large scale, and to-day we bear witness to the fact that the ultimate solution of the great problems of highway and highway transportation development rests largely in the hands of the college-trained engineer.

The Bureau of Education, by means of different investigations, has ascertained that highway constructors and administrators, with few exceptions, are seeking for at least twice as many trained engineers and other men as have been needed in the past. At the same time greater emphasis is being laid upon the character of the education and training that these men need.

In the words of Prof. Gordon Vernon Skelton, of Oregon State Agricultural College, "there are fewer lines of public endeavor where more money is being spent and where a higher degree of technical skill and training is required than in the field of highway engineering."

At present there is a greater demand for nearly all types of engineers than before the war. President Lovett, of the Union Pacific Railroad, has recently pointed out that the railroads must expend nearly a billion dollars annually for new railroads and for the repairs made necessary by the forced neglect of these vast properties during the recent war period. Thus there will be an increasing demand for railroad civil engineers in addition to the greater demands for highway engineers. This condition of affairs places an unusually heavy burden upon the engineering colleges of the country. It will be the duty of this conference to ascertain as definitely as possible the extent of this burden.

THE COLLEGES OF ENGINEERING AND THE HIGHWAY ENGINEERING PROBLEM.

One hundred and fifty universities and colleges in the United States are offering one or more subjects in the various branches of the engineering profession. Of these institutions, 111 give courses in one or more subjects in highway construction. These institutions include the colleges and schools of engineering in 65 State universities, including colleges of agriculture and the mechanic arts, 32 large privately endowed universities and colleges, and 14 smaller colleges. In at least 15 of the larger engineering colleges curricula are offered which include an option in highway engineering. These options usually consist of from two to five subjects treating on specific problems of road construction.

The colleges of engineering are working out the problems of highway engineering from four different standpoints: *First*, by means of the regular four-year civil engineering curricula leading to the de-

gree of bachelor of science. *Second*, by means of the short, special, and extension courses which may vary in length from a few days or weeks to two-year courses in which road building is given practical consideration. These courses attract the more advanced type of farmer and young men of the rural districts who are not prepared to carry on collegiate work. These courses are calculated to give in the shortest time possible the rudiments of highway construction and repair, and later serve to stimulate a sentiment in favor of high-grade road construction in the counties and districts from which these men come. *Third*, by mutual cooperation of State and county highway departments in using the testing laboratories in the engineering colleges and engineering experiment stations. *Fourth*, by means of graduate work and research in highway engineering problems.

TYPICAL HIGHWAY ENGINEERING CURRICULA.

The typical highway engineering curricula of to-day are composed of a suitable grouping of foundation and supporting subjects in the humanities and the pure sciences, combined with a larger grouping of engineering or technical subjects. An interesting four-year civil engineering curriculum recently elaborated is that of the new school of engineering of Harvard University. About 35 per cent of the entire curriculum is devoted to the following foundation and supporting subjects: One year of college English, two years of higher mathematics, one year each in chemistry, physics, and geology, and one year in an additional science, one year in business administration and accounting; two years' work in a modern foreign language is required if the student has not made it a part of his preparatory work. Over 50 per cent is prescribed in the usual civil engineering courses, and 2 per cent is required in specific highway construction courses. A little over 12 per cent of the curriculum is devoted to elective subjects.

The curriculum in civil engineering of the Oregon State Agricultural College is typical of the curricula of a number of the leading State-supported colleges of engineering. It differs from the Harvard curriculum as follows: The requirements in foundation and supporting subjects are 39 per cent, or 5 per cent greater than at Harvard, but this includes the addition of military training, gymnasium, and a brief course in library practice. Consequently, the relative proportion of the foundation and supporting subjects are essentially on a par with that of Harvard. Sixty-one per cent is prescribed in the usual civil engineering subjects, but this includes an option which may be chosen in highway engineering to the extent of three courses, in addition to the regular course in roads and pavements. All these courses amount to nearly 11 per cent of the entire curriculum.

A few colleges of engineering, which offer options in highway engineering, require two years of modern languages, usually French or German, but the larger proportion do not require these subjects. The subjects of economics, business administration, and contracts and specifications are included in the majority of curricula, inasmuch as the civil and highway engineer must be equipped to deal intelligently with the business aspects of his profession. From the evidence which the Bureau of Education has received, the present trend of practice in colleges of engineering is not to encourage a large degree of specialization in the civil engineering curriculum.

SHORT, SPECIAL, AND EXTENSION COURSES IN ROAD CONSTRUCTION.

Typical among the institutions which offer short and special courses in road making are the following: The University of West Virginia, which holds a four-day conference of all State road officials, followed by a three-day school for general instruction. Extension schools of two and three days' length are held at convenient centers in different parts of the State. These courses are open to all who are interested in good roads, regardless of college entrance requirements or previous experience. The University of Tennessee offers a short winter course for highway engineers which lasts six weeks. The last two days of the short course is devoted to an annual conference of road officials. On this occasion all persons interested in any kind of highway work are invited to attend. The University of Georgia "good roads department" is organized to give direct instruction and field assistance throughout the State. Special courses of instruction are offered at the university, chiefly for the benefit of county officials and other mature special students. Maryland State Agricultural College offers an elementary course in the location, construction, and maintenance of county roads and bridges: this is a part of the two-year course in mechanic arts. Many other similar examples might be given, but these are sufficient for our purpose. Furthermore, an excellent opportunity is open to our public high schools, both rural and urban, to teach the rudiments of the economics of highway transportation in order that the growing generation of young men and women may understand the relation of good roads to national prosperity.

COOPERATION WITH THE STATE.

Owing to the lack of proper facilities, the State highway departments and commissions have in many instances been obliged to obtain the cooperation of a number of the leading State universities and colleges in working out the practical problems and tests called

for in the highway construction work in the States. At present there are at least 10 institutions whose laboratories are used in testing road material for the States in which they are situated. These institutions are Iowa State College, Georgia Polytechnic Institute, University of Idaho, Kansas State Agricultural College, University of Kentucky, University of Maine, University of Michigan, University of Minnesota, University of Missouri, University of Nevada, and Ohio State University. This cooperation has enabled a great many students to come in contact with the practical work of the highway departments of the different States.

RESEARCH IN HIGHWAY ENGINEERING.

In the future our larger engineering colleges will play a much greater part in highway engineering and construction than in the past, owing to the increased demand for research work in the various branches of highway construction. In recent years some very important experiments in highway engineering have been carried out by our State universities which have proved to be of great financial value to the States and to the Nation. In view of the extensive road-building program which is now going into effect, the organization and execution of a well-coordinated plan of highway engineering research will be of first importance. With this in mind, the division of engineering of the National Research Council is planning to distribute to the various higher engineering institutions research problems in highway engineering which must be solved in the near future. We may therefore expect that the universities of the country will make useful contributions to the program of road building, and instead of a few scattered experiments with more or less duplication of effort, systematic research will now be undertaken.

Already a number of leading engineering schools have ample facilities for carrying on first-class graduate work in highway engineering leading to the master's and the doctor's degrees.

HIGHWAY TRANSPORTATION ENGINEERING EDUCATION.

Perhaps the more difficult of the two complicated problems facing the engineering colleges is that of preparing highway transport experts. Granted that our highway engineers will prepare suitable roads for the growing number of automobiles and motor trucks, the great question, the final cause of all our efforts, is the planning of an automotive transportation program commensurate with the rapidly growing needs of this country. The continued expansion of internal commerce which has been so marked since the war is demanding an output of motor trucks and automobiles that will

create a volume as well as a variety of traffic and the consequent economic problems which can not be solved by the novice.

At least 12 colleges and universities of importance are giving attention to the subject of transportation, and especially in the field pertaining to railroads. Full four-year curricula in railroad transportation are offered by the University of Illinois and the Wharton School of Commerce and Finance of the University of Pennsylvania. Little has been attempted in highway transport education. However, it is due in large measure to the leadership of Prof. Arthur H. Blanchard, formerly of Columbia University and now professor of highway engineering and highway transport of the University of Michigan, that highway transportation education is commencing to be recognized as one of the coming engineering specialties of importance.

The help which the colleges and universities of the United States are giving in preparing men to meet these vital needs of the country places the Nation, the States, and individuals under great obligations to our colleges for the services they can render, and at the same time there is placed upon these institutions an important responsibility which they alone can perform.

THE CONFERENCE COMMITTEE ON HIGHWAY ENGINEERING EDUCATION.

MEMBERS OF THE COMMITTEE.

Chairman: Thomas H. MacDonald, chief of the Bureau of Public Roads, United States Department of Agriculture.

Secretary: W. K. Hatt, head of the School of Engineering, Purdue University.

P. St. John Wilson, chief engineer, Bureau of Public Roads, Washington, D. C.

T. Warren Allen, general inspector, Bureau of Public Roads, Washington, D. C.

E. J. James, assistant chief engineer, Bureau of Public Roads, Washington, D. C.

Paul D. Sargent, chief highway engineer of Maine, president of American Association of State Highway Officials, Augusta, Me.

W. G. Hoyt, assistant chief, water resources branch, Geological Survey, Washington, D. C.

Lieut. Col. J. M. Ritchie, Motor Transport Corps, United States Army.

A. N. Johnson, consulting engineer, Portland Cement Association, Chicago, Ill.

H. G. Shirley, secretary and treasurer, Federal Highway Council, Washington, D. C.

Charles E. Ferris, dean of the School of Engineering, University of Tennessee, Knoxville, Tenn.

Hector J. Hughes, professor of highway engineering, Harvard Engineering School, Harvard University, Cambridge, Mass.

C. J. Tilden, professor of engineering mechanics, Sheffield Scientific School, Yale University, New Haven, Conn.

R. H. B. Begg, professor of civil engineering, Virginia Polytechnic Institute, Blacksburg, Va.

John R. Lapham, assistant professor of civil engineering, College of Engineering, George Washington University, Washington, D. C.

EDUCATIONAL SUBCOMMITTEE.

W. K. Hatt, secretary.

Hector J. Hughes, associate.

C. J. Tilden, associate.

PROGRAM.

1. Personnel needs of the districts under the supervision of the Bureau of Public Roads:
   - (a) Available supply and future requirements indicated by definite percentages. Losses due to deaths and resignations. The increase in the amount of work to be done.
   - (b) Should permanent advisory board attempt a control of the highway engineer supply through limitation of students permitted to take a highway engineering course when there is an oversupply or to induce students to take such a course when the supply is insufficient.

2. Duties of highway engineers:
   (a) Commissioner, director, or chief of Federal, State, county, town, or city highway department, bureau, or board.
   (b) Chief engineer of one such highway bodies.
   (c) Assistant chief engineer or member of chief engineer's staff.
   (d) Division or district engineer.
   (e) Resident engineer.
   (f) Chief of party, transitman, levelman, rodman, or draftsman.
   (g) Bridge engineer or bridge engineer assistants.
   (h) Chemist, testing engineer, geologist.
   (i) Economist, research engineer.

An extract from the report of the Congressional Reclassification Commission is attached for reference.

3. Education for highway engineers:
   (a) Full graded-school and high-school work and a college undergraduate course of four years, leading to what degree? Is any other length of undergraduate course suggested?
   (b) Should the first two years of the college course be purely a civil-engineering course, with the highway engineering subjects confined to the third and fourth years of a civil-engineering course? If so, what proportion of the third and fourth years should be in highway engineering, what subjects each year, and the number of hours?
   (c) How much highway transport work should be given to an undergraduate electing highway engineering, in what years, what subjects each year, and the number of hours?
   (d) Should there be an attempt to secure as a part of the complete college course practical experience during summer vacations by arrangement with organizations doing highway design, construction, and maintenance?
   (e) Research work for the highway engineer undergraduate.
   (f) Postgraduate course—of what it should consist, number of years required to complete the course, months during the year suggested for the course, and hours in each year.

THE PURPOSE OF THIS SECTION.

The question discussed by the Section on Highway Engineering was:

How shall a supply of trained men be secured for highway engineering from graduates of engineering colleges and through short courses and graduate courses? What cooperation may be secured between the State highway commission and the colleges to make use of the facilities of both organizations in reciprocal service?

Having defined the character of the service to be rendered by highway engineers, what studies of the curriculum will be most useful in training men for such services?

The discussion, therefore, followed the following lines:

A. Needs of personnel:
   (1) Number of men needed each year for highway organizations.
   (2) Supply of trained men from colleges.
   (3) Control of supply of trained men.

B. Duties of highway engineers:
   (1) Specification of duties.
   (2) Salaries.

C. Education of highway engineers:
   (1) Education of highway engineers.
   (2) Relation of colleges to highway organizations.
   (4) Postgraduate courses.

ABSTRACT OF DISCUSSION.

The discussion may be abstracted as follows:

A. *The needs of personnel.*

From the data submitted it appeared that the need of trained highway engineers, inspectors, etc., far exceeds the supply now available. An annual increment of 1,100 graduates is needed, whereas the supply of civil engineers of graduates of all branches is only approximately this number. The suggestion was made that some central body should supply information to the colleges of the opportunities and openings in highway engineering, so that the senior class might intelligently dispose of themselves.

B. *Duties of highway engineers.*

The specifications for the job and for the qualification of men to perform the duties and discharge the responsibilities attached to the job were recited; the scale of salaries now paid and proposed to be paid. It appeared that the latter were not large enough to compete with industrial opportunities. The difference might be overcome by creating ideals of public service.

C. *Education of highway engineers.*

The relative importance of fundamentals and special applications in education was discussed. The need for studies other than of technology to prepare a man for administration and for citizenship was emphasized. The situation in the colleges, which are struggling under an overload with a diminished teaching force which is competed for by the industries, was forcibly described and the necessity of public support of these institutions strongly stressed.

The need for connecting up the colleges with the highway commission for reciprocal service was also emphasized.

The difficulty of synchronizing the college program with the construction period was noted. The summer employment of students in services of increasing importance in succeeding vacations was suggested as a valuable means of training, especially if it were related to the term instruction. The residence of the technical staff of the commissions at the university for short periods, and the formation

of classes for further study at the headquarters of the commission were suggested as additional means of training.

Research by undergraduates seemed to the conference to be limited to short problems, which, however, might be a part of a general field, apportioned by a central body. Training in research methods and the generation of the spirit of research among undergraduates was more important than the particular results.

Proceedings of the Conference Committee on Highway Engineering.

CHAIRMAN: THOMAS H. MACDONALD.

(A) NEEDS OF PERSONNEL IN HIGHWAY ORGANIZATIONS.

(1) *Needs of highway organizations in personnel.*

Mr. MACDONALD. The first subject is assigned to Capt. Wilson—Personnel needs by Bureau of Public Roads districts.

Capt. Wilson read figures from a table prepared from data received from 30 State highway departments, as cited in Mr. MacDonald's paper. (See p. 33.) These data showed that a total of 312 engineers were employed by the Bureau of Public Roads at Washington and in the field. Thirty-six States reported 3,939 engineering employees and 2,628 additional in county and other organizations, or 5,667 total.

The percentage of the several grades are:

	Per cent.
1. Above division engineer or similar grades	5
2. Division engineer or similar grades	12
3. Resident engineers or similar grades	26
4. Grade below resident engineer	51
5. Unclassified	6
Total	100

It was estimated that the needs of the next decade would be from 9 to 12 per cent per year, but that the per cent is probably far short of the actual number that will be required as the standards of the counties continue to be raised and as the maintenance is placed more and more under technical direction.

As further indications of future needs, the paper by Mr. MacDonald quotes the following data:

Total expenditure for highways, by years, in the United States.

Year.	Total.
1916	$272,634,413
1917	279,915,332
1918	286,098,192
1919 (estimated)	303,670,105
1920 (estimated available for expenditure)	783,000,000

Because of the industrial and transportation situation it is probable that only 50 per cent of the amount available for 1920 can be spent.

The extension of engineering control of expenditure and increased need for engineering beyond the proportion of money available is shown in the following data: The per cent of construction funds expended under the control of trained engineers for the year 1916 was 27 per cent; 1917, 35 per cent; 1918, 41 per cent; 1919, 46 per cent; 1920, 81 per cent.

Maintenance of highways by organizations operated by engineers also demands a supply of trained men. Of the total miles of highways, the State highway departments maintained 3 per cent in 1916; 7.3 per cent in 1917; 8.1 per cent in 1918. The field of maintenance is of increasing importance.

A. N. JOHNSON. Did the figures given in your paper take into account deaths, resignations, etc.?

Capt. WILSON. Yes. In the letters sent to the State highway departments the following sentence was included: "It should be borne in mind that the need will be caused by deaths and resignations, as well as increase in the amount of work to be done."

Mr. HOYT. The United States Geological Survey finds that the turnover to keep up the normal is somewhere around 20 per cent.

Mr. BEGG. Has there been any attempt to find out whether the shortage is due to a shortage of engineers or to salaries?

Capt. WILSON. Both. If we paid higher salaries we could get men, although the number of highway engineers is limited. The amount of work has increased very much more rapidly than the opportunity to train the men. A quarter of a million dollars was spent in 1916, and there is three times that amount to spend this year, and three times the amount of work to be done. Very few men have been going into highway engineering during the last three years.

CHAIRMAN. I have a total of approximately 6,000 men reported employed by the 30 State highway departments. That is an average of 200 to the State. At that rate 48 States would employ 9,600 men. These are men who should have engineering training and do not include some of the lower positions. The annual needs would be 10 per cent of 9,600 or 960 engineers. If our estimates are correct, when the present freshmen class graduates there will be approximately 5,500 engineers graduating. The needs for highway engineers will require approximately 20 per cent of the entire number of engineering graduates.

Mr. SHIRLEY. So far as I can see, the importance of highway engineering has not been impressed upon the educators as it should be. The demands in the past will sink into insignificance in comparison

with what they will be in the future. Highway construction is going to increase and increase. Many new problems in research are coming up. Therefore there is no speculation in training as many men as can be secured.

(2) *Supply of trained highway engineers.*

CHAIRMAN. What is the estimate of the number of engineering graduates that are civil engineers?

Dr. HUGHES. About 20 to 25 per cent graduate in civil engineering now.

Prof. HATT. About 20 to 25 per cent.

Prof. TILDEN. Rather high; I think under 20 per cent. The mechanicals and electricals have been running rather higher.

CHAIRMAN. At the rate of 20 per cent rate there would be approximately 1,000 or 1,100 graduates in civil engineering. If these estimates are at all correct, this number would just meet the requirements of the State highway departments, provided every man went into the highway work.

Prof. HATT. The graduates in civil engineering from Purdue University have entered highway engineering work as follows: 1913, 8 per cent; 1914, 8 per cent; 1915, 13 per cent; 1916, 10 per cent; 1917, 19 per cent; 1918, 21 per cent; 1919, 26 per cent; 1920, 23 per cent.

In motor-transport work from the school of mechanical engineering, including the manufacture of automobiles, sales, maintenance, research: 1916, 13 per cent; 1917, 21 per cent; 1918, 33 per cent; 1919, 27 per cent; 1920, 38 per cent.

This year the balance has been disturbed, because it is the first time the manufacturing concerns have been canvassing civil engineering seniors for employment in manufacturing, mainly with a view to sales engineering. For instance, one company manufacturing road machinery is paying $150 to $175 a month to our seniors to go into its factory; and the highway commission is paying $125. It is difficult to persuade seniors to enter the latter.

CHAIRMAN. What is the average per cent that might be counted on to go into the highway work?

Prof. HATT. It is difficult to predict the quantity. The springs of action moving our students are difficult to determine. They lie back in the high schools, and magazine literature, and student boarding houses.

Dr. HUGHES. One of the springs is very clearly defined. In my office, where all the work of nine different programs comes in, during the past week there have been 20 representatives of industrial firms, electrical and mechanical chiefly, offering the men $125 and $150, and, in one case, $175 to start, and one of them offered $225 at the end of six months. The highway engineers can not be placed at

such prices, and until something is done to make the highway work attractive we are not going to attract civil engineers into this kind of work. When the Harvard departments were working at the Massachusetts Institute of Technology there was a regular highway program which graduated a number of students. I have talked with a number of them since. They wish they had not gone into highway work. They say: "We go into highway departments and they give us work for the summer, and when January comes they do not need us; or we have to take a civil-service examination to get a job." That is one of the real situations. In fact, that is what your chairman said this morning. It is a matter of inducements.

(3) *Control of supply of highway engineers.*

CHAIRMAN. If we have discussed the present need sufficiently to fix some figures in our minds that are not very definite, but, perhaps, estimate the requirements, we shall pass to the next topic: Should the permanent advisory board attempt a control of supply of highway engineers through the limitation of students permitted to take a highway-engineering course, when there is an oversupply, and inducing students to take such a course when the supply is insufficient?

Prof. HUGHES. There is probably no more important problem at the present time in the schools of this country, technical and otherwise, than to find some intelligent means for fitting men to places. I don't see how that can be done for highway engineers until we find some way of doing it for all sorts of engineers. If sufficient inducements were made in the positions which are open to civil engineers, it would be a very simple matter to divert men to the highway work, say, at the beginning of their senior year. The places open to them now are not attractive as compared to the places which they can get immediately in particular industries or regular engineering work. Telephone companies are taking electrical engineers, starting at $150 a month.

There is another phase that is even more important. I have been told by some young men that a good man, after having been, for example, an engineer for some time in an electrical company, has a very good chance to get into some of the executive departments. I do not see that we have very much to offer men in highway engineering departments beyond strictly technical places; so that there is not the advantage, which many students look upon as a very important one—that of getting into highly paid executive positions. There ought to be something done to make those inducements. For example: The textile industries of New England up to date have had very few trained men. They will take all the men we will send them, and are willing to train them at their own expense. At the end of five years the men are likely to have $10,000

or $15,000 jobs open to them. We have not got those jobs for highway engineers. If they go into the contracting business they may expect such compensation.

One thing can be done. There ought to be some agency which will keep the schools informed of opportunities in highway engineering. In New England we learn of the opportunities in New York State and in the United States Government, but nothing of what is open in Illinois. If the schools had systematic information, gathered together from all over the country, of what jobs are open and how to get those jobs, it would materially help in inducing a man to pursue highway engineering as a future profession. The real trouble is lack of inducement.

Mr. HOYT. The welfare of the individual student must be consulted. The industrial conditions which prevail at the time a freshman graduates will be very uncertain. He should have a broad three years' engineering education, and at the end of three years he will be able to branch out into a specialty. If some opening could be established whereby the colleges could be informed of the demands in various fields, the men of the senior class, in consultation with the professors, could switch from one field to another.

Prof. TILDEN. I should like to ask just how an advisory board could control the highway engineering supply? What would be the basic organization of such a board?

CHAIRMAN. This same question is troubling the chairman. This was not my question; it was Prof. Hughes's question.

Prof. TILDEN. An important point to consider in this matter of any attempt to control is the lag of supply behind the need under the present system. For instance, if there is a strong demand one year for graduates in mechanical engineering, that becomes apparent not only to the senior class but to the students in the lower classes of the school who are just making the decision as to which lines, civil, electrical, mechanical, or chemical, they are going into. A sudden increase in the demand for chemical engineers this year is going to have its effect in inducing a number of freshmen, sophomores, or juniors into choosing that line of work, and these men come up as available material three years or two years or a year later. At that time the industrial demand may be partially met, and there is at the same time the oversupply from the schools. That particular phase of the time factor, it seems to me, would be an important one.

Prof. HUGHES. It is the whole question, and, of course, one way to help this is to avoid a choice any earlier than necessary, but it is wider than that. I do not see how you can do it until you can find a far more intelligent basis than we now have for adapting men to the work for which they are suited and training them for it.

Prof. TILDEN. Fluctuations in the demand are going to occur at much shorter intervals than the four-year curriculum.

A. N. JOHNSON. While many of the industries to-day, in the need of the hour which is very pressing, do not hesitate to offer these rather large inducements, is it not a fact that a very large percentage of industries, as compared with public work, go in peaks and drops? The first inducement is to get graduates in. Then is no assurance how long they are going to stay. Thus it may happen that in a year or two hence, when there is no demand, these men may be thrown out in the world, and, because the drop in industrial conditions may last for a few years, they may be thrown out not for the winter months but for two or three years. On the other hand, most of this public work is far more stable and is not all subject to the fluctuations that the industrial situation is subject to, and there is more of a reasonable opportunity for permanency in the career, which, I think, can very well be brought out and should be brought out. I am not by any means arguing that the present inducements of salaries are anywhere near sufficient.

Prof. HUGHES. There is another side to what Mr. Johnson says. I think industrial conditions have very materially changed. With the shortage of labor there is a very much increased demand for permanent positions for trained men in the industries. For instance, the great textile industries of New England have almost no trained scientific men. They are getting to need them more and more. With the shortage of labor the problem of production is increasing in importance. I believe, myself, from a recent study, that there is going to be a permanent demand in the industries for these men.

Mr. SHIRLEY. The turnover that has taken place in the highway engineering has been a great deal more rapid than in any industries. Two and three-quarters years is the average life of office of an engineer commissioner. Certain States have civil-service laws which only allow voters and residents to get in under civil-service laws. That is going to operate against any plan you may have to qualify men for this specific work. Those men, regardless of how well qualified they are, will not be available for that State.

(B) DUTIES OF HIGHWAY ENGINEERS.

CHAIRMAN. It seems to me that a part of the question concerning the opportunities for engineers, particularly for executive positions, might be discussed under the next topic—Duties of highway engineers. The committee has outlined a discussion, based on the different grades of engineers that exist in the different departments, but it seems to me that a somewhat more logical division is that made by the Reclassification Commission into certain groups—the five profes-

sional and two subprofessional groups. If it were possible to recognize certain classes or grades of engineers and secure a definition of their duties, one leading directly to the next higher, as in the proposal in the Government service, that would open to the students the steps of advancement that lead to the higher positions. If such a plan were generally adopted, not only in the Federal Government, but in the State departments as a whole, would not the engineering instructors be able to say to the students: "Here's your line of public service?"

Mr. HOYT. The proposed classification of the congressional committee is as follows:

EXTRACT FROM REPORT OF CONGRESSIONAL RECLASSIFICATION COMMISSION (FOR EDUCATIONAL CONFERENCE, MAY 14 AND 15, 1920).

JUNIOR ENGINEERING AID.

Specifications of class.

Duties.—Under immediate supervision, to perform miscellaneous subordinate work in the laboratory, office, or field, or any branch of engineering.

Examples: Setting-up apparatus; making simple engineering computations; compiling field data or laboratory notes; filing and indexing maps, plans, and notebooks; preparing samples; caring for instruments in the field or laboratory; working as rodman, chainman, or tracer; making blue prints.

Qualifications.—Common school education; good health.

Promotion.—To civil engineering aid.

COPYIST DRAFTSMAN.

Specification of class.

Duties.—Under immediate supervision, to make tracings from original drawings prepared by others; and to perform miscellaneous routine work in a drafting room.

Examples: Making simple tracings; copying data; filing and indexing under supervision; lettering; making simple drawings and diagrams; making hand corrections on printed charts.

Qualifications.—Training equivalent to that represented by graduation from high school; knowledge of the use of drawing instruments, and ability to use them neatly.

Promotion.—To civil engineering draftsman.

CIVIL ENGINEERING AID.

Specifications of class.

Duties.—To perform under immediate supervision minor technical work in any branch of civil engineering; and to perform related work as required.

Examples: Making measurements and estimates in the field; acting as recorder or computer in laboratory, field, or office; operating and caring for sur-

veying instruments; computing data for reports of records; plotting notes and maps; preparing working drawings where design is furnished.

Qualifications.—Training equivalent to that represented by graduation from high school; not less than two years' experience in engineering work; familiarity with the use of the slide rule; and ability to do lettering and drafting, and to make simple engineering computations.

Promotion.—From junior engineering aid to junior civil engineer.

CIVIL ENGINEERING DRAFTSMAN.

Specifications of class.

Duties.—To perform under immediate supervision routine drafting work in connection with the preparation of plans for civil engineering projects; and to perform related work as required.

Examples: Making tracings from original drawings; making drawings of minor importance; filing and indexing drawings; lettering, computing, and revising.

Qualifications.—Training equivalent to that represented by graduation from high school; not less than two years' experience in engineering drafting work; and ability to letter and to make simple calculations.

Promotion.—From copyist draftsman to junior civil engineer.

JUNIOR CIVIL ENGINEER.

Specifications of class.

Duties.—Under immediate supervision, to perform routine surveying, computing, drafting, and inspecting, on survey, construction, or valuation work, and to perform related work as required.

Examples: Surveying with transit or level; using measuring devices for stream gauging; inspecting structures during construction and after completion; assisting in laboratory tests of structural materials; preparing charts for statistical and engineering data; laying down lines for building foundations; drawing and tracing plans; making plans; table surveys; developing and drawing details of maps and charts; lettering; giving lines and grades for highway construction; keeping cost data; serving as boat officer or as assistant in hydrographic, geodetic, and astronomic parties.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing; with major work in engineering, preferably in civil engineering.

Promotion.—From civil engineering aid, civil engineering draftsman, to assistant highway engineer.

ASSISTANT HIGHWAY ENGINEER.

Specifications of class.

Duties.—Under specific administrative and technical direction, to be in responsible charge of a minor subdivision of a highway engineering organization; to collect and compile data for specific items of highway engineering studies; to take immediate charge of field survey projects in, or the design, inspection, or construction of minor highway engineering work; to lay out and develop

work from specifications, and to supervise the work of a drafting or computing force; to conduct specific tests or investigations of apparatus, material, or processes; and to perform related work as required.

Examples: Making surveys for the purpose of securing data for highway construction; making and reviewing plans, specifications, and estimates for highways; compiling data on, and inspecting quarries, gravel pits, and crushing plants; superintending the maintenance of experimental roads; assisting in experimental research and in the testing of road materials.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in civil engineering, preferably highway engineering; not less than two years' experience in highway engineering work in field or office, proven technical knowledge and proficiency.

Promotion.—From junior civil engineer to associate highway engineer.

ASSOCIATE HIGHWAY ENGINEER.

Specifications of class.

Duties.—To perform one or more of the following functions under general administrative and technical direction: (1) To be in responsible charge of an intermediate subdivision of a highway engineering organization; (2) to exercise independent engineering judgment and assume responsibilities in studies and computations necessary in the preparation of reports, estimates, or designs; (3) to have immediate charge of the construction, maintenance, or operation of important highway engineering works or projects; (4) to direct or perform important researches in highway engineering; and to perform other related work.

Examples: Making surveys and estimates in connection with highway construction; investigating and reporting on methods of road construction; testing road materials; reviewing plans, specifications, and estimates, and making recommendations in regard to them; assisting in installing improved methods of State management of highways; laying out country systems of highways.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in civil engineering, preferably in highway engineering; not less than five years' general engineering experience, of which at least one year shall have been in the direction or performance of important highway engineering work; and supervisory or administrative ability or a high degree of technical skill.

Promotion.—From assistant highway engineer to highway engineer.

HIGHWAY ENGINEER.

Specifications of class.

Duties.—To perform one or more of the following functions under general administrative direction: (1) To have responsible charge of, and to initiate, and execute policies for a major subdivision of a highway engineering organization; (2) to prepare for final executive action, reports, estimates, specifications, designs, and data; (3) to have charge of the construction, inspection, maintenance, and operation of highway engineering works of major importance; (4) to conduct or to direct major lines of highway engineering research; (5) to furnish for executive action, expert or critical advice on highway engineering works, projects, or policies; (6) to act as special advisor on highway engineering problems; and to perform other related work.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in civil engineering, preferably in highway engineering; not less than eight years' general engineering experience, of which at least four years shall have been in the direction or performance of important highway engineering work; large capacity and demonstrated ability and experience in the administration of highway engineering work.

Promotion.—From associate highway engineer to senior highway engineer.

SENIOR HIGHWAY ENGINEER.

Specifications of class.

Duties.—To perform one or more of the following functions: (1) To have chief administrative charge of a highway engineering organization; or of a main division thereof, and to determine or execute general policies under the limitations imposed by law, regulations, or other fixed requirements; (2) to be responsible for reports, estimates, designs, specifications, and data, or for the construction, maintenance, and operation of large highway engineering projects; (3) to direct or to perform the most comprehensive research in highway engineering projects, policies, or valuations; and to perform other related work.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in civil engineering, preferably in highway engineering; and not less than 12 years' general engineering experience, of which at least 8 years shall have been in the direction or performance of important highway engineering work of a character to give substantial evidence of engineering knowledge and ability, or of executive capacity, of the highest order.

Promotion.—From highway engineer to chief.

CHIEF.

Specifications of class.

Duties.—Executive and technical supervision over work.

Qualifications.—Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in civil engineering; extended professional experience, of which at least eight years shall have been of a character to give substantial evidence of knowledge and ability, and of executive capacity of the highest order.

Promotion.—From senior highway engineer.

Mr. HOYT. The basic principle on which these principles were worked up are, first, the kind of work involved; and, second, responsibility attached thereto. An effort was made to have them so general that they would apply to any branch of engineering.

For instance, in the junior grade, which is the lowest professional grade, a man must have as a basic requirement a college education or the equivalent in one of the lines of engineering. He would work in that grade under direction and under supervision until he demon-

strated his ability to work independently or to supervise others. Then he would be promoted to the assistant grade, in which he would have responsibility for independent work under very general direction and also have responsibility of supervising in a very limited way the work of others. The assistant grade is that in which the rank and file, about 80 per cent of engineering employees, will have to work, and an effort was made to fix the salary for that grade as high as possible, because the chances of getting out of that grade into a higher class are rather limited.

For promotion to the associate grade there must be a demonstration of more ability to do a higher grade of work.

Going down to the lower grades there is a definite subdivision between the professional man and the subprofessional man. The specifications drawn up by the commission were primarily adapted to the Government service in Washington. In studying these in connection with the Engineering Council, we found it necessary to carry the subprofessional grade higher than the Reclassification Commission did. Therefore we have overlapped.

Now, this grade of subprofessional is the limit for the man who has not the educational qualifications to go up into the higher grades of engineering work and design. We propose to divide those two grades of men into such a subdivision or classification as would make possible an equitable salary adjustment in accordance with the responsibilities of the position and the ability of the man to do the work, the two principal factors to be taken into account. Of course, the higher up the fewer positions there are to fill. Only comparatively few men can ever reach the higher positions, so that salaries must be provided sufficient to satisfy men in the intermediate stages. That has not been done in the salary adjustments. The higher places pay much more in proportion than the intermediate places in which most of the men are employed. This fact has caused the discontent among engineers and is responsible for the tendency toward unionization which is quite a sentiment throughout the country for some sort of an organization to promote the interests of the now unorganized men.

Mr. MACDONALD. While the specification that was finally adopted by the Reclassification Committee goes at the matter from a slightly different angle, is it not general enough in its character to permit the classification of all highway department employees under its division? Are these specifications not sufficiently extended to classify these men as far as need be? We are not particularly interested in the specific duties of the different classes of men?

Mr. HOYT. In that connection I think the committee should consider the addition of a highway subprofessional grade. There are only two subprofessional grades designed for persons in the Wash-

ington service. There is a highway grade, which never goes into the full professional work; the subprofessional, which is very important to the organization, including foremen, superintendents, and men of that class. They are more or less artisans, or men who would never go to the top. By additional study they may come up to the professional grades. As a general proposition the committee would do well to differentiate between the professional man and the subprofessional man. These are two distinct fields, and they need different training.

The CHAIRMAN. I have referred to these specifications because they were arrived at after consideration of a rather wide variety of services and because it seems to me it would not be desirable to try to limit grades too closely. The requirements and duties of our highway engineers will change from year to year, and it seems to me that it is desirable to have a general classification, with their responsibilities and duties fixed, rather than a specification of titles as Chief Engineer, or Resident Engineer or Bridge Engineer, etc.

Mr. Hoyt has given an outline of the professional grades of engineering service as outlined by the Reclassification Commission. Now that committee did not fix a salary for the senior grade, but for the engineer of second grade, for which the recommendations range from $4,140 to $5,040.

Salaries of highway engineers.—The following schedule shows the comparison of salaries in the Bureau of Public Roads in 1919 as compared with those in the various States and those recommended by the Reclassification Committee, grouped under these several divisions:

Rank.	Bureau of Public Roads, both office and field, exclusive of bonus.			Compensation in various States;[1] reclassification basis			Recommended by reclassification.		
	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.
Senior	$4,500	$4,500	$4,500	$5,000	$7,150	$10,000	.....	.....	.....
Engineer	2,500	3,641	4,080	2,820	4,307	5,000	$4,140	$4,590	$5,040
Associate	2,280	2,656	3,240	2,200	4,100	6,000	3,240	3,540	3,840
Assistant	1,560	2,141	3,000	2,100	2,635	3,300	2,400	2,700	3,000
Junior	950	1,537	2,100	900	1,835	3,060	1,800	1,980	2,160
Civil engineer aid	720	860	1,080	800	1,043	2,080	1,200	1,500	1,800
Junior engineer aid	480	767	1,080	480	915	1,500	840	1,020	1,200
Copyist	540	760	1,080	.....	1,200	.....	1,080	1,170	1,260

[1] Massachusetts, Wisconsin, New York, Delaware, Maryland, Michigan, Pennsylvania, California, Texas, Iowa, Illinois, Indiana, New Jersey, Ohio—14 States.

From these it will be noted that in the 14 typical States having well-organized highway departments the salaries are higher than those recommended by the Reclassification Commission, and very much higher than those now paid by the Bureau of Public Roads.

But even this schedule is lower than the recommendations of the American Association of Engineers or the Engineering Council. The recommendations of this association are shown in the following schedule:

Rank.	Compensation.	
	Minimum.	Maximum.
Senior	$8,000	$15,000
Engineer	4,000	8,000
Associate	3,600	5,000
Assistant	2,400	4,000
Junior	1,800	2,400
Engineer aid draftsman	1,800	2,400
Junior engineer aid	1,200	1,800
Copyist	1,800	2,400

Prof. HUGHES. One of the big milling machine companies of which I know has quite a large group of men out of college a year, each of whom is paid $4,600 a year. If they are out four or five years their salary is $10,000 or $12,000.

CHAIRMAN. Mr. Allen, can you outline the divisions on the schedule under topic 2, showing the different offices in a highway department? That would give something of an outline to the representatives of the colleges of the grades into which these different lines of work would fall.

Mr. ALLEN. (*Reads from schedule.*) (See extract from report of Congressional Reclassification Committee, p. 59.)

CHAIRMAN. The district engineers would fall into the second class. Does that give any indication of the relative responsibility these engineers would carry?

Prof. HUGHES. If the salaries in general available throughout the country for highway engineers were raised to such a standard as that, a large number of men would be available. There still remains in my mind what I have noticed in the minds of the students. When they have reached that grade there is nothing left to them except a commissioner's job. They don't feel that they have the future that a big industry offers.

CHAIRMAN. It was that statement that made me desire to bring out this point. As a matter of fact the engineers in the departments today are the men who are doing the executive work. The commissioners in many cases are acting more as an advisory or directory board rather than as an executive board.

Prof. HUGHES. I mean by commissioner a director.

CHAIRMAN. I think you will find in the duties of the two higher grades, and possibly the three higher grades, specific directory charge over others. The men in these grades have supervisory charge in re-

sponsible positions. You will see that a number of existing positions would fall into one of these grades, either 1, 2, or 3.

Prof. HUGHES. When it is realized that the big industries would absorb graduates into positions that would pay as large salaries, the opportunity does not appeal to these ambitious men.

Prof. HATT. I think Prof. Hughes has struck the keynote here. I have noticed for a number of years that students have been discontented with purely technical work. A sales engineer gets $7,000 or $8,000 a year, and so students are seeking entrance to the industries rather than to purely technical positions.

Prof. TILDEN. I do not think that that question ought to be put solely on a compensation basis. Interest in the work is a very large factor. Of course a man must have a certain minimum salary. He wants to have a reasonable outlook for the future, but if it was only money he was looking for our graduates would all go into plumbing or bricklaying.

CHAIRMAN. I think you are right in that matter, Prof. Tilden, that the compensation can not be pecuniary entirely, but it will have to be sufficient so that a man can support himself and his family comfortably. After that, is not the big problem to set up ideals of public service that will draw men into these positions? Is not that the big problem before this conference, trying to set up the ideals of public service that will attract men and change the public sentiment that apparently is all directed against the public service. In some countries a man can belong to governmental and State service and walk right up the street. In this country apparently it is necessary to take to the alleys or by-roads. It ought to be permanent service and on a graduated basis.

(C) EDUCATION FOR HIGHWAY ENGINEERS.

CHAIRMAN. While the committee on program has outlined our work to cover the technical requirements here, I am not sure that that is the big question. The third topic—Education for highway engineers—will be opened by Mr. Ferris.

Mr. FERRIS. I believe most of us agree that there has been a tendency too far in specialization. * * * Highway transport work is also new to us except in a few institutions, and with a few exceptions we are quite at sea. I can not pretend to answer any of the questions set out. I am very anxious to know what the decision of this conference may be.

If I have anything of real value to offer to you gentlemen, it is based on a little experience of our own. My message is in the interest of the man who is not working for a college degree at all. You can not run an army without a large number of noncommissioned officers,

and you can not build highways without a lot of noncommissioned men. You spoke this morning, Mr. Chairman, on the immediate need of men to do our work. We can not wait four years. In Tennessee we have adopted the following plan which grew out of our short courses of two or three days, or four or five days.

Our short course is a slack-season course. You generally hear suggested that highway engineers are taken off the pay rolls in January and February, the slack months. If not taken off the employer is glad to find them willing to leave the pay rolls, so we have established a winter short course of six weeks. We undertake to draw into that course, not the college-trained man, but the man of experience who is doing the work. As Mr. MacDonald said this morning, they do put the thing over. We are not willing to throw out of employment the man now building highways, but would like to make him a better highway builder. The short course has done much along that line. We give these men work in the laboratory, in the drafting room, in mathematics, in the use of instruments, adjusting and care of instruments, and a strong course of lectures in highway engineering and highway construction. We give elementary courses in mechanics. We do not require them to take them. They have some selection. The course has helped the counties and the highway department to get better men.

CHAIRMAN. This topic will be discussed further by Prof. Tilden.

Prof. TILDEN. This question, Mr. Chairman, is really one of construction along lines in which I have been particularly interested and in which most of us in educational work are most vitally interested now, namely, the construction of the college curriculum. This is one of the largest construction problems before engineers now. In trying to find some definite solution, it has been borne in on me that we have been building college curricula heretofore only in two dimensions. We have so many hours per week on one dimension and have so many weeks, 15 in a term, or four years in the other dimension; and in that plan, bounded by those two linear dimensions, we have a certain topic or a certain field. The most important part, the most vital factor in educational value, in any course of study is in the third dimension, the dimension that builds it up, which could be represented, perhaps, more by the intangible factor, or the less precise and definite factor, of the personality of the teacher and the inspiration he is able to give his students, secured by a teacher of intellectual training and leadership. So that when we come to discuss how much highway transport work should be given to an undergraduate, or the length of the undergraduate course, those are questions which are concerned in the two dimensional aspects of the case. To use a rather extreme instance, I believe that a man would be better fitted to build bridges, or at least

to learn how to build bridges, or to build highways or to handle an executive job of any kind, if he had had a three-hour-a-week course in Greek under a man like Gildersleeve than he would if he had had a more specialized course under a man who had not the inspiration and power to bring out the intellectual side as a real teacher has. I do not want to answer this question, Mr. Chairman, except in that way.

Therefore, how much highway transport work should be given to an undergraduate depends on how much real inspiration the teacher can develop in the students. That is the main thing, and it is the thing we are far too apt to neglect. It becomes a very important question just now, when we are having so much trouble in getting teachers who are able to handle any of our courses. I should like to leave the question with just that one idea and give the rest of my time to those who will discuss it.

Mr. HOYT. I believe the needs of highway work and the work on which I am engaged—hydraulic work—are better filled by a man who had a good fundamental education without any specialization. At the end of six months we can give a man more training than he can get in two years in college training. The fashions in highway building or other engineering work change about as fast as fashions in women's styles.

Prof. HATT. One eminent teacher used to say that a college curriculum could not be standardized, because it was determined by the personality and training of the particular professors on the staff. In his view, which agrees with Prof. Tilden's view, a course was a vehicle by which a general end was attained. I think that this view is rather extreme.

Col. RITCHIE. I think the keynote has been struck. Take highway engineering. From the military standpoint, it is my opinion that it would be better to have a man take four years of a real engineering educational course than a course in highway engineering. If he wants to specialize, all right. Specialists do not have much of a place in the Army outside of Ordnance or Signal Corps. A man may be building a bridge to-day, a warehouse to-morrow, or a sea wall next week, and when he gets in the zone of action he may be repairing shell holes to-day and building wire entanglements to-morrow. So that the field for specialists in military work is very limited.

There is one point I have noticed in the last 20 years of my experience, and that is that very few engineers have been taught economics, statistics, cost accounting, etc. I think that every course should take this into consideration in connection with the development of the engineer. So far as highway transport is concerned, outside of maintenance, which requires mechanical ability, it is largely one of business administration, and also a knowledge of accounting.

being able to make traffic surveys, and how to dispatch vehicles. I think it is largely one of business education rather than of technical education.

Mr. MACDONALD. Has it been your observation, Col. Ritchie, that men with engineering training did better in the transport work than men without that training?

Col. RITCHIE. Absolutely. A man who is technically trained fits more readily into any niche, regardless of where he is, than a man who is not so trained.

Mr. SARGENT. It was my observation that all engineers, taken as a group, have not had a broad enough training in the fundamentals—I do not mean fundamentals of engineering, but the fundamentals the colonel spoke of, economics, business training, and the social side of engineering; that is to say, it has been my observation that they do not have the proper conception of the problem as a whole. Their vision is too limited, is bound up and down by technical limitations.

Mr. MACDONALD. Do you have difficulty, Mr. Sargent, in picking out a man to send into different parts of the State to talk before the people when you have a difficult situation to be met?

Mr. SARGENT. I can't find them; I can't do it myself.

Prof. HATT. What the college does is to train men. The college student gets training, while the man in the field gets experience. The aim of this training is a mind that will think clearly and straight, which can quickly comprehend complicated situations, and analyze them to their elements, which assembles well-determined facts before drawing conclusions. The atmosphere indicates ideals also.

Now, this training may best be secured, as far as it is possible to train individuals, when the student is interested in a subject that is related to something he expects to do in later life. There is, I think, a misconception concerning "specialization." Like "technical" and "abstract," it may connote unfortunate tendencies in education.

With us a "special course," in the senior year, presents a situation in which a small group of men come into intimate contact with a professor who knows his subject theoretically and practically, then learn its setting, go with him to the library, study broadly and deeply. Is this not a proper vehicle for training, regardless of the subsequent employment of the student?

The engineering professors are moving away from the rather narrow and technical treatment of topics; they demand less "rivet spacing" from students. We are introducing more of economics, business law, corporate organization, finance, public speaking, etc. Business law obtains an excellent reaction from the student. It is really a humanizing study.

Of course, in a desire to develop general mentality we must not forget we are training engineers with good habits, that demand formal patterns in field notes, laboratory exercises, reports, and drawings. Pure ability will not go far in engineering without these handmaids of performance. There is a danger of loss in our new emphasis on general mentality. As to another phase of so-called specialized instruction, my information is that there is but little migration of civil engineering graduates to purely mechanical or electrical fields or vice versa, after graduation. The few that so migrate will not determine questions of curricula. The large migration is into business, in banking, for which a civil engineering course is a very good preparation.

A course in roads and pavements extending throughout one year is, in my opinion, a fundamental course in civil engineering curricula and may be taught broadly. Every State needs men trained in the fundamental principles of building and maintenance. We have passed the pioneer days, and such courses should not be limited to a few centers. With the assistance of lecturers from the field of practice, which from the standpoint of training of students should be quite limited in amount, a technical school in each State should be able to conduct such courses.

Mr. Begg. I have just passed through the painful experience as chairman of the committee revising our engineering course. One group wants the course so broad as to crowd out all technical subjects, another group wants a particular technical specialty allowed so much time that general education would suffer.

In a four-year technical course, I do not see where there is room for both a general education and thorough technical training. It seems to me if the engineering colleges can come to the same custom that the other professional schools have—law and medical—we can maybe get somewhere. In a medical school they do not attempt to give any general education, but they expect their men to have a general college education before they come to their professional course. It seems to me the engineers will have to do the same thing. Everyone knows the engineer has to have a general knowledge of English. It takes three years to get that. I suppose that instruction should be given in a modern language, which most of the technical schools provide. That will also take two years after high school. There is mentioned business law, economics, social science. Now by the time the student has had training in all these he has taken up four years and there is not time for special training.

We must divide the work. Let the liberal arts colleges give the general education and the technical schools the technical education.

Another point is that a purely technical school can not usually afford to have the very highest grade of men for the general subjects.

Of course the technical schools are supplying the good grade of technical men.

As to a general education, so far as the technical school can give it, I suppose what we want in the end is to build up a man on the fundamentals of mathematics, economics, etc., with ability to apply these to any line of work. Certainly he gets as good a training in mathematics by studying such a subject as bridge design as he would by going on for a long time in pure mathematics. A good deal of his economics can be gotten about as thoroughly in a good course of highway or railroad economics. So that a great deal of that general class of knowledge he should be able to get in a technical school course if properly taught.

As far as a specialization is concerned, he should not begin the specialization too early. If a man is allowed in his fourth year to put more of his time on one of the different branches of civil engineering (structural, railway, highway, or sanitary), he practically takes that specialty, and if he is interested will get more out of it. The general training is practically as good in one as the other, so that even supposing a man put the bulk of his time on highway work and later went into a sanitary concern his time would not have been wasted. He would get the training in methods of study and of obtaining information on a given subject, and that would be as useful in one branch as the other. So I like the idea of allowing a man in his last year to specialize considerably on the branch he is interested in, even allowing for the fact that a great many men will not stay in that branch they have specialized in.

Mr. MacDonald. Are there any other discussions on this same subject—"Education for highway engineers"—or any other suggestions?

Mr. James. If the committee does report on specialization in highway work, there are certain details, certainly from the standpoint of the Bureau of Public Roads, that are not touched on at all in a specialized course that should be touched on. Methods of surveying that apply to railroad work are used in a general way for highway work. For instance, college men seem to know nothing about "backing down a hill." Our highway surveyors will back down a hill to get a line. Men come out of college knowing nothing about the interpretation of tests, especially in bituminous work. All they know is whether the material conforms to the specification or not. If there are wide ranges in the possible mix, and the mix is running close to the maximum or minimum range, they do not know where to put their bitumen. In grading concrete aggregates the methods now used and the shortage of materials require refinement if we are going to use a lot of material which we really ought not to discard. We get men out of colleges who do not know the first thing about

those things. It seems there are a lot of details in specialized courses that should be worked out, and men should be filled as full of those things as they can be.

Mr. MacDonald. In my judgment you are mixing things up for these educators and have really brought out two rather different lines of study. Surveying, which is fundamental in the engineering course, was founded, of course, in railroad methods, and highway engineering has suffered because railroad engineering was the first engineering discovered. In fact, we all tried to use railroad engineering on highways. I do not know anything that suffered more than highway bridges because they followed railroad bridges. Now, surveying is a rather fundamental thing in civil engineering. That is not what you call a specialized course.

Mr. James. When they come to specializing in the highway engineering course those conditions should be brought out.

Mr. MacDonald. What we want them to do is to teach surveying and not teach railroad surveying. When we come to those other points, the analysis of bituminous materials, etc., that comes into another field somewhat more highly specialized. You would not consider that a fundamental course in civil engineering.

Prof. Hatt. It is said that the courts follow public opinion in their judgments, and it would seem just as natural that engineering curricula should change with the changes in industrial conditions. We have cut down the number of hours devoted to railway engineering largely in the last few years and are putting more into highway engineering.

Mr. Hughes. A great many schools are teaching some of the subjects Mr. James mentioned, not with the idea of railroad engineering or surveying alone.

Prof. Hatt. It is agreed that the graduates must have the fundamentals of general training in mathematics, science, and language, and in the foundations of engineering technology, and that they should be furnished with some of the tools of their profession, such as drawing and surveying.

At present a proposal to lengthen the period of training—to give more years—seems impracticable. Speeding the student as he was speeded up in training camps, providing a more orderly and efficient administration of studies to avoid duplication, a diminution of the distractions of the college campus, the better use of the library and laboratories, the shortening of vacations, a scientific study of the teaching process—all of these may accomplish the results of the five-year course. But the data for judgment upon this question are not available.

There remains the consideration of adjustments of subjects. The older civil engineering curricula provided for the three then prevail-

ing demands for trained men in surveying, railroad engineering, and structural engineering. For a period of years the large majority of the graduates entered professional service through the railroad maintenance of way or construction corps or through the drafting rooms of the structural-steel companies. It is a fair question to ask if the amount of time devoted to the direct preparation for these services may not be diminished. Surveying has in some cases been transferred to a summer session.

There was also a period of overstressing of technical performance of field work, shop drawings, track details, and mechanism. A survey of present courses in respect to such details may disclose an opportunity for a consideration of such subjects in the field of the highway engineer such as the technology of bituminous roads.

It is by such means that the courses in economics, business law, spoken English, etc., have been introduced for the purpose of getting an engineer for community life and administrative duties.

By some of the means suggested there should be found a place in the junior year for a three-hour-a-week course in roads, such as pavements, considered as a fundamental course in civil engineering to include the bed, the foundation, and the surface of the various classes of roads. Such a course should involve the disclosure and application of the underlying principles. The element of information that a man properly trained in the use of books can afterwards secure should be minimized.

As to optional or special courses for men in the senior year the following considerations are offered: Such men as graduates are primarily to be trained to think clearly and straight, to analyze complicated situations to their elements and to learn the proper methods of work. A valuable vehicle to this end is an optional study in highway engineering in the senior year—equally valuable, indeed, with sanitary engineering or railroad engineering when a student comes with interest and a definite purpose. The desired qualities may be secured with any one study, and are ready for application in any field.

Such an option for three hours a week throughout the senior year is recommended to include, among other things, the economics of highway transportation, taxation, and finance, the relation of the traffic to the roadbed, the organization of administration, and a study of systems of production.

Lectures by specialists from the field of construction and production are available and should be used to the extent where they will not interrupt the reaction and work of the student.

Colleges may well supplement the academic instruction by organic relations with the highway commission, providing for supervised and consecutive summer employment of students, for instruction of mem-

bers of the technical staff of these commissions either in part-time residence or by extension.

A further source of increased efficiency of road work is the road school or conference held at the university for a week or two in the winter season.

Mr. MACDONALD. On No. 3, the education for highway engineers, I presume it was the idea of the committee that we should prepare a course or suggested course for teaching highway engineers. Fundamentally, the impression that I have received from this afternoon's talk is that, in the first place, there is no agreement upon the exact lines that we shall follow in educating engineers, how far we shall go to specialize courses. In the second place, I am greatly impressed—impressed as I never have been—by the necessity that the highway departments, the organizations using highway engineers, should connect up with the universities and colleges so that they will both understand the other's viewpoints and limitations and requirements. For instance, there is a greater opportunity in highway engineering to-day than is evidently in the minds of some of the educators. These salaries of highway engineers are temporary. They will be raised. There is an opportunity for public service that has not been impressed upon the educators. That has been the fault of the highway departments, I believe. It is not my desire to impress my viewpoints on this committee. I do not know whether you have obtained the same impression that I have, that there is a rather greater problem before the committee than the number of hours that should be devoted to any particular subject, and that is, the coming together, the meeting of the minds of the educators and the men who desire to use highway engineers, or the highway departments. Is there any other discussion with reference to this topic 3 that ought to be left with the educators?

Mr. A. N. JOHNSON. What can be done by this committee to get the salaries of teachers raised? It seems to me that part of the work of this conference should be to open up channels of publicity that should simply put before the people, who have voted millions for roads, the condition now prevailing—that these universities are broke and can not pay teachers' salaries, and the public must maintain them.[4]

[4] NOTE BY EDITOR.—Mr. MacDonald's address has emphasized the following situation: "But consider the case of educational institutions which we are calling upon to train engineers." Under war conditions the teaching staffs were badly disorganized. Last year there was a tremendous influx of new students, and the appropriations have, in general, been less than the enlarged needs. Salary budgets have not been revised to meet the competition of industrial engineering organizations, with the consequent loss of very many of the best qualified professors and instructors.

The instructor who, during prewar times, has taught a specialized course in some particular phase of engineering, such as highway engineering, is called upon to go into general teaching or to spread his activities over for a greater number of students than he can possibly give proper attention. Educational institutions have necessarily given up their building programs in order to hold their teaching staffs together, while the

RELATIONS OF COLLEGES AND HIGHWAY ORGANIZATIONS.

Mr. MACDONALD. The next topic is, "Should there be an attempt to secure, as a part of the complete college course, practical experience during summer vacations by arrangements with organizations doing highway design, construction, and maintenance?" Mr. Johnson has consented to discuss this subject.

Mr. JOHNSON. It has been generally conceded in engineering work that it is desirable for the student, if possible, to find some employment in his line or prospective line of endeavor during the vacation period. Now, it is a fact that usually at the time he is to return to college he leaves at just the time the highway work has reached practically the peak, along in September, and then it is difficult for the highway organization to get anyone to fill out the season to take his place. It seems to me, if it is considered desirable that students in engineering colleges, presumably taking highway work, should have this summer experience, that it might be found expedient to change the time of closing and opening the schools that their services might fit in a little more with the season in which they would be desirable. That is, if the colleges would close about the first of June and would let these men stay out until October, they would be of some real value in their work. Is it desirable for them to be away from their college work that length of time? I think very few college courses would be greatly shortened if the Christmas and Easter vacations were eliminated and that time put into the entire summer vacation period, on the assumption, however, that the students would be practically obliged to take up outside work and could secure it.

Mr. HUGHES. At the University of Pittsburgh, where they have this scheme, they modify the program for civil engineering by providing for three months of study and three months of work for three years. At the University of Cincinnati they have a concentrated scheme to keep civil engineers occupied in contract and construction experience during the time when the opportunities are most available.

Prof. HATT. Our difficulty is that the schools of engineering and of agriculture want the students out at different times, so that classes in departments of common subjects, such as mathematics and English, can not operate with a balanced load.

Mr. SHIRLEY. You can not operate until you get a whole group of students working by themselves.

---

additional room is seriously needed. Our institutions are suffering from an unforeseen expansion while they can not capitalize, to provide funds, as in the case of the industries, and a condition has resulted which the public must understand and provide for. That our educational institutions can not be neglected is a fundamental creed with the greater part of our citizenship, but the present conditions must be understood and given the proper publicity.

Mr. ALLEN. It is, I think, unquestionable that experience in the actual design, construction, and maintenance of roads will enable the student to obtain a much better understanding of the principles involved in road work. Practical application of principles is vitally necessary in order to fix them firmly in the mind and show their use in the solution of problems in highway engineering. For example, I would suggest that the student, during the freshman vacation, should spend his time as a member of a road survey party, spending some time as a chainman, some time as a rodman, some time as a levelman, and some time as a transitman. He should obtain experience in recording field notes. During the sophomore vacation, if the freshman vacation has been properly spent, I would suggest the time be directed to office work on the plotting of survey notes, the laying of grades, the computation of quantities, and the preparation of cost estimates. The junior year vacation would seem wisely spent on construction, getting experience as an instrument man in the staking out of work, the inspection of materials and work, and the preparation of partial payment estimates, both field and office work.

On the student's return to college following each vacation, he should be thoroughly examined in order to ascertain what progress he has made during the vacation. The result of such examinations might well be used as a guide in the handling of the student during the subsequent months of college study. It might also be used to determine whether further experience along the lines of that had during the vacation just concluded is necessary during the vacation the following year, or whether the preliminary experience is sufficient for the purpose, and the student may be permitted during the following vacation to obtain the more advanced experience. If his experience at the end of the junior year vacation is found to be insufficient, it might be advisable to oblige him to make it up following the end of the senior year before fully graduating him.

This is a very brief outline, but in my opinion it indicates approximately the course which might well be pursued in supplementing the study required during the undergraduate course by practical experience during vacation time.

Prof. HATT. Is it possible to send young engineers on the staffs of highway commissions to the universities for further study? The universities might form some organic connection with the commissions.

Mr. MACDONALD. For what period?

Prof. HATT. In Indiana, January, February, and December.

Mr. JAMES. We are trying to make them busier then.

Mr. SARGENT. I think this is a good suggestion, but how far the highway departments would be able to put it into operation I am not prepared to say. I am positive that in our own department we have

worked every man since the end of the last open session that we found room to work, and now we have not more than from one-half to two-thirds of the work done which we expected to have done at this time. I am just speaking from my own point of view. We would not have been able at any time last year to have laid off men for a month or six weeks. It would have crippled the work we had in mind to do. I think that is true of most of the State highway departments which have had this large Federal aid program on hand. However, in ordinary times, when the organization is built up and more or less work is going over from one year to another, I think it would be possible to let the younger men go for a period of one or two months in the winter at a profit to the whole organization, keeping them on the pay roll.

Mr. MACDONALD. The next subject is: "Research work for highway engineer undergraduates."

Mr. GOLDBECK. That is a subject that has been discussed by the other committee to some extent. I have outlined a proposed scheme for research work. In a very general way, I want to say a few words about it. In the first place, any course in college should be made for the purpose of training the mind of the student and to give him special or general knowledge to enable him to carry on his work in later life. Now, research work, I should say, ought to be conducted for the same purpose. In other words, if he conducts research work it should be conducted for the purpose of training, not for the purpose of gathering information which will be of particular value to the highway engineering profession. The graduate student, however, can conduct research work, perhaps, in a year's time, and the results that he obtains may, perhaps, be of some value. In conducting such work, though, it seems to be advisable that it should be thoroughly outlined by some central body, such, perhaps, as the engineering division of the Research Council or, perhaps, a committee composed of a number of engineers—State highway officials. Even for graduate research work the researches must be short. In other words, I do not feel that, in general, graduate research work can be conducted on the big major problems. Major problems can be divided into certain minor problems, and these can be attacked by the graduates.

Prof. HATT. I suppose the question as to whether or not valuable research may or may not result from institutions where graduate students are not in residence is to be settled on the basis of experience. Certainly it can not be denied, for instance, that the earlier researches from the University of Illinois were of great value, and these were successful because inspired and directed by Prof. Talbot, working with senior students, who afterwards, became very productive research workers. We should not create a hierarchy of research.

By all means create an atmosphere of research in college laboratories where graduate schools do not exist.

I think the spirit of research could be stimulated if the National Research Council, or this governing committee, would draw up a comprehensive program and let the student understand that he is making the researches as a part of the big national program. Now, those results do not have to be accepted, but it is barely possible that some of the research work conducted would be of value, in which case it could be accepted, but the very fact that the students know that they are working on a big, comprehensive program would be a stimulus to them.

POSTGRADUATE COURSE.

Mr. MacDonald. This topic is properly followed by the "Postgraduate course." Prof. Agg is not here, and I shall call for a volunteer. Dr. Hewes, you have given the subject considerable thought. Do you wish to open the discussion?

Dr. Hewes. Mr. Chairman, how much have you agreed should be given the undergraduates? All research work done by students must come in the graduate course, and it would seem that the trend of opinion is that the research work done, even by the graduate students, should be limited, at least in our expectation of results from it, to the operations of an assistant. Now, as to the content of the curriculum, if we provide a course in rolling stock in the graduate years, that is to say, in the economics of automotive transport, including the relationship between public expenditure and question of how much the public is going to receive from its investment in highways, that would presuppose, possibly, that the usual year course in economics be followed by another in taxation or interest. It seems to me, also, that the question of administration is one that might better be studied in a graduate course. That is, what are the functions of the administrator which the highway engineer should perform, or to what degree should he extend his functions as an engineer into the functions of a public official—what should be his relationship to the public? Questions of that sort naturally will fall on more fertile ground in the graduate than in the undergraduate years.

It has been said that we do not know what kind of road to build. A certain amount of investigative work would naturally fall in the graduate course. I think, possibly, we could learn from the wonderful example of the school of Ponts et Chaussées, in France. It would be advisable to have some one thoroughly investigate and digest what training they give their engineers. For one thing, they teach much more mathematics than we do. We generally stop teach-

ing mathematics at the time the student ought to begin to use it, and he should, therefore, be given some advanced mathematics, assuming that a graduate course would be two years. Doubtless we should give a graduate course in chemistry, chemistry in hydrocarbons and in cement. How much more descriptive and cultural work should go along with it I am not prepared to say. All through these graduate years there should be a coordinate course in English composition, to develop the capacity of men to report on subjects in intelligible English. If they have to appear before a board of commissioners, they will be able to present the engineering features in their report in an effective way and get away from the slide-rule attitude.

RESOLUTIONS OF THE COMMITTEE ON HIGHWAY ENGINEERING.

Need for highway engineers.—The moneys at present available for highway construction under engineering control total approximately $800,000,000. The engineering staff needed for this control will require an annual supply of 900 college-trained civil engineers, in addition to the highway engineers employed by the counties and other municipal divisions.

The supply of highway engineers.—The civil engineering schools will graduate probably not more than 1,100 students three years from now. This quota is competed for by the railroads, construction companies, and the industries, and by the county and municipal organizations. Probably not more than 300 would be normally available under the influences operating at present to fill this quota of 900.

Means of increasing the supply.—The attention of the colleges is called to the importance of highway transportation, and the service they can render in training men to direct the expenditure of public money derived from taxation on roads that will carry the traffic of to-day and to-morrow.

The professors of civil engineering are urged to direct the attention of their students to this field of stabilized professional service and to inculcate ideals of public service as opposed to private gain. A sense of the high calling of the civil engineer in professional service needs stressing at the present time.

In order that the colleges may provide facilities and a trained staff for instruction and research in highway engineering, more ample funds must be provided from private sources, from cooperative efforts with industries, and from taxation. At present the colleges are staggering under an unexpected load, and are under emergency conditions.

Federal and State commissions should provide the salaries adequate to secure recruits for and retain the staff of our Federal and State highway organizations. Such salaries should be large enough to free the professional staff from the economic pressure of the industries, in which responsibilities less heavy and demanding less preparation are more amply remunerated.

Cooperation of colleges and highway commissions.—As a means of increasing the number of trained men available for the staff organizations of highway commissions and the Federal services, it is recommended that plans of cooperation be secured between the colleges and these organizations to provide for summer employment of students which shall be related to the college instruction, and for further study by college graduates on the staff of the commission, either through part-time residence at the college or by extension classes operated by the colleges with the assistance of the executives of the commission.

A centralized body should supply information to the colleges of the opportunities and openings for engineering graduates in highway engineering.

The short courses, given by the colleges, to road officials of the county, are commended as a very fruitful source of inspiration and instruction leading to better road building and maintenance. In all this work the element of inspiration and of sense of responsibility should not be minimized.

Course of instruction.—The highway engineer deals with the public, and with the broad issues of State and national affairs. He needs a training in the fundamentals as related to modern life. He must also be an engineer trained to high technical standards, and in the method of work of the scientist. Therefore, the subjects of English, economics, science, and business relations are important. Training in technic should be thorough and severe. Highway-engineering subjects supply an excellent means of training in the several elements mentioned. A course in roads and pavements, extending throughout one year, is considered a fundamental subject in the civil-engineering curriculum. A special optional course, in the senior year, presents a situation where the student is interested, becomes motivated, has intimate contact with the professor, who is a competent practitioner as well as a teacher, and has an opportunity for library research and individual expression. Such specialization is highly educative, and the ordinary objections to so-called specialization do not obtain. The changing industrial and economic conditions are necessarily reflected in college curricula. The diminishing draft upon graduates for railway engineering may properly operate to adjust curricula which were devised a decade ago.

Research.—It is a matter of common knowledge that research workers receive an impulse to research and learn the methods and standards of research from a professor while undergraduates in college. When working under direction, results of value to industry are secured by these students. When research is planned and coordinated after several years, the results are substantial. The extent of the unexplored field of research in the design of pavements and in the properties of materials of construction as related to service conditions, combined with necessity of throwing early light upon these problems, calls for a mobilization of all the resources of the testing laboratories in equipment, research teachers, and student workers, and for an appropriation of some portion of construction funds to provide support for this research.

W. K. HATT, *Secretary,*
Head of the School of Civil Engineering,
Purdue University.
HECTOR J. HUGHES, *Associate,*
Professor of Civil Engineering,
Harvard University.
C. J. TILDEN, *Associate,*
Professor of Engineering Mechanics,
Yale University.

19813°—21——6

CONFERENCE COMMITTEE ON HIGHWAY TRANSPORTATION EDUCATION.

MEMBERS OF THE COMMITTEE.

Chairman, George C. Diehl,
Chairman Good Roads Board, American Automobile Association.

Secretary, Arthur H. Blanchard,
Professor of highway engineering and highway transport, University of Michigan, Ann Arbor, Mich., and president National Highway Traffic Association.

Raymond Beck, chief Goodrich Travel and Transport Bureau, Akron, Ohio.

Roy D. Chapin, president Hudson Motor Car Co., Detroit, Mich.

P. P. Claxton, United States Commissioner of Education, Bureau of Education, Washington, D. C.

F. W. Davis, consulting engineer the Pierce-Arrow Motor Car Co., Buffalo, N. Y.

William B. Doron, Ship-by-Truck Bureau, Firestone Tire & Rubber Co., Akron, Ohio.

M. O. Eldridge, director of roads, American Automobile Association, Washington, D. C.

Ernest Farr, director, Firestone Ship-by-Truck Bureau, Akron, Ohio.

H. S. Firestone, president Firestone Tire & Rubber Co., Akron, Ohio.

E. T. Herbig, secretary-treasurer National Association of Motor Truck Sales Managers and sales manager Service Motor Truck Co., Wabash, Ind.

W. D. Hines, Firestone Tire & Rubber Co., Akron, Ohio.

A. O. Horrocks, Goodyear Tire & Rubber Co., Akron, Ohio.

E. R. Jackson, Ordnance Department, War Department, Washington, D. C.

E. W. James, assistant chief engineer, United States Bureau of Public Roads, Washington, D. C.

Clyde Jennings, managing editor, Automotive Industries, 239 West Thirty-ninth Street, New York, N. Y.

Emory H. Johnson, dean, Wharton School of Finance and Commerce, University of Pennsylvania, Philadelphia, Pa.

John R. Lapham, assistant professor of civil engineering, George Washington University, Washington, D. C.

R. E. McDuff, Packard Motor Car Co., Washington, D. C.

J. Clyde Marquis, The Country Gentleman, 1128 Munsey Building, Washington, D. C.

C. M. McCreery, transportation division, Goodyear Tire & Rubber Co., Akron, Ohio.

A. Osmun, captain, Motor Transport Corps, United States Army, Washington, D. C.

C. S. Pike, Paige Motor Co., Detroit, Mich.

C. W. Reid, manager Transportation Bureau, Federal Highway Council, Washington, D. C., and vice president National Highway Traffic Association.
Lee L. Robinson, Transportation Section, Council of National Defense, Washington, D. C.
Harry M. Rugg, director technical instruction, United Y. M. C. A. Schools, 347 Madison Avenue, New York, N. Y.
Paul D. Sargent, chief highway engineer of Maine, Augusta, Me.
Alex Summers, United States Bureau of Education, Washington, D. C.
Richard Waterman, Chamber of Commerce of the United States, Wells Building, Washington, D. C.
John Weber, associate professor of mechanical engineering, University of Pittsburgh, Pittsburgh, Pa.
S. M. Williams, chairman Federal Highway Council, Washington, D. C.
J. W. Witt, vice president National Highway Traffic Association and president Nagle, Witt, Rollins Engineering Co., Dallas, Tex.
T. B. Taliaferro, dean, School of Engineering, State University of Maryland, College Park, Md.

EDUCATIONAL SUBCOMMITTEE.

A. H. BLANCHARD, secretary.
EMORY H. JOHNSON, associate.
JOHN WEBER, associate.

PROGRAM OF THE CONFERENCE COMMITTEE.

1. What number of men is it estimated will be required by the automotive industries in the following fields in the next five years and, in a general way, what should be their different educational requirements?
   (*a*) Automotive engineers in research and design work.
   (*b*) Sales engineers.
   (*c*) Advertising, business administration, and office work.
   (*d*) Motor-truck fleet managers.
   (*e*) Shop foremen, skilled mechanics, and inspectors.
   (*f*) Highway transport engineers in highway departments.
2. How many colleges should undertake this work?
3. How much highway engineering should be included in the highway transportation course?
4. How many years of study and how many hours per year should be given in these courses?
5. Should this work for the mature men be undertaken in special advanced courses outside of the usual university courses?
6. How much training is necessary in the vocational field? Should the industry undertake to train these men or should the work devolve upon automobile schools?
7. High-school education.
8. Resolutions or reports summing up the viewpoint of the committee on these subjects.

Report of Proceedings of the Conference Committee.

Chairman: ARTHUR H. BLANCHARD.

DIGEST OF DISCUSSIONS ON THE TOPICS INCLUDED IN THE PROGRAM.

1. What number is it estimated will be required by the industry in the following fields in the next five years and, in a general way, what should be their different educational requirements?

(*a*) *Automotive engineers in research and design work.*—Based on an estimated annual production of 300,000 motor trucks and 2,000,000 touring cars, the general consensus of opinion was to the effect that 1,000 automotive engineers for research and design work should be graduated each year by universities and that these men should be trained through the medium of four years' mechanical engineering courses which include automotive engineering options.

(*b*) *Sales engineers.*—It is conservatively estimated that 3,000 men should be trained each year as sales engineers. It was pointed out that men in this field should sell transportation as well as trucks. It was not considered that undergraduate college training was necessary but that it was desirable. In order to acquire knowledge of highway transport these men should be trained through the medium of short-period advanced courses in universities specializing in this subject.

(*c*) *Advertising, business administration, and office work.*—The opinion was advanced that not less than 200 advertisers should be trained each year along the lines advocated for sales engineers. Several officials of motor vehicle companies expressed the opinion that men who will occupy executive and administrative positions should be broadly trained college graduates who had specialized in economics, business administration, and similar subjects, and who had later taken graduate short-period courses in highway transport. For routine office work it is considered that a high-school training followed by special training in commercial schools would provide a satisfactory educational equipment.

(*d*) *Motor-truck fleet managers.*—It is conservatively estimated that 1,000 men per year should be trained for these positions. During the next five years at least 90 per cent of this number should be trained in universities through the medium of short-period advanced courses in highway transport, while from 50 to 100 men per year should be trained by attending four-year highway transportation engineering courses.

(*e*) *Motor-truck operators.*—The development in the utilization of motor trucks and available statistics was the basis of the conserva-

tive estimate that 200,000 operators should be trained each year in plants, vocational and automobile schools.

(g) *Highway transport engineers in highway departments.*—It is recommended that engineers for these positions should have had training in the field of highway engineering, and should take short-period courses in highway transport. It is estimated that 175 per year will be needed for positions in State, county, and municipal highway departments.

2. How many colleges should undertake this work? It was the consensus of opinion that 10 universities, located in different geographical sections of the United States, should offer short-period advanced courses in highway transport, and four-year courses in highway transport engineering or highway transport options in four-year collegiate or technical courses.

3. How much highway engineering should be included in the highway transportation course? It was generally agreed that not less than 30 lecture hours should be devoted to the fundamentals of highway engineering for men specializing in highway transport.

4. How many years of study and how many hours per year should be given in these courses? It is conservatively estimated that men specializing in highway transport should devote the equivalent of one collegiate year to work in this field.

5. Should this work for mature men be undertaken in special advanced courses outside of the usual university courses? The answer to this question was unanimously affirmative. It was pointed out by several representatives of the industry that the University of Michigan's plan of offering a series of two-week courses during the winter meets the demand for short-period advanced courses in highway transport.

6. How much training is necessary in the vocational field? Should the industry undertake to train men or should the work devolve upon automobile schools? Those who had had experience in this field of educational work stated that 35 hours per week for four to six months was required for training in this vocational field. It was recommended that industry and vocational schools should work out an effective and cooperative educational plan.

7. High-school education. It was the consensus of opinion that pupils in grammar and high schools should be taught traffic regulations and the fundamentals of highway transportation as it affects daily life.

HIGHWAY TRANSPORTATION ENGINEERING CURRICULA.

Discussion by ARTHUR H. BLANCHARD, professor of highway engineering and highway transport, University of Michigan, and president National Highway Traffic Association.

In the opinion of some, highway transport may not be considered as belonging both to the field of technical training and education. On sober thought, however, it will be seen that this branch of knowledge comes well within the classic definition of engineering embodied in the royal charter of the Institution of Civil Engineers of Great Britain, which, in part, is as follows: "The art of directing the great sources of power in nature for the use and convenience of man as the means of production and of traffic in states, both for the external and internal trade."

Before discussing the subjects which should be included in a technical course for highway transport engineers, a brief résumé of the development of motor transport and highway improvement in England and the United States will be presented in order to give some indication of the possible demand for men trained in highway transport engineering.

In England, the improvement of the main county roads preceded the development of highway transport. When transportation of heavy loads of commodities over highways was inaugurated prior to 1890, England did not have to wait for the construction of highway systems, with the result that rapid growth of highway transport took place. As early as 1891, Fletcher, an English author, in writing on "Transportation on common roads," considered some of the classes of highway transport now under discussion in the United States and cited many instances of conflict between highway authorities and highway transport interests regarding some of the fundamentals of highway design. The writer, while investigating highway transport in England in 1909 and 1910, encountered the same problems with reference to highway transportation and legislation that exist in this country to-day. Pratt, in 1912, in his treatment of the subject of inland transport in England, presented many of the phases of the problem now confronting us with reference to what he called "Back to the land movement." It is evident that a thorough study of English highway transport methods and legislation would be of material benefit to American engineers and traffic managers who are striving to develop efficient highway transportation.

During the past decade the United States has witnessed a rapid growth in the utilization of the motor vehicle, as indicated by a registration of 125,000 motor vehicles in 1908 and 7,558,848 in 1919. While in 1909 a motor truck was rarely seen on American highways

outside of municipalities, in 1919 not less than 750,000 were in use in the United States, motor trucks constituting from 10 to 20 per cent of the registered motor vehicles in the several States. Highway improvement has not kept pace with the increase in the utilization of motor vehicles. The fundamental basic axiom that economic highway transport is impossible without good roads should be fully recognized. A review of the present status of highway improvement in the United States indicates that there are about 2,500,000 miles of rural highways; that 12 per cent are classified as improved; and that about one-fourth of 1 per cent are suitable for trunk highway motor-truck traffic. Highway conditions will be materially improved during the next decade, as is indicated by the 1920 appropriations of about one billion dollars for highway improvements and the widespread demand for the construction of a system of 50,000 miles of national highways by the Federal Government under the direction of a national highway commission.

The breadth of training for highway transport engineers should be far more comprehensive than has been considered necessary for many technical branches. Breadth of knowledge is essential from a utilitarian viewpoint, as the highway transport engineer must, in many fields, deal with social and economic conditions, and must always have before him the fundamentals of sound business methods.

Comprehensive courses in highway transport engineering should include the following business and engineering subjects, in addition to the usual fundamental humanistic and pure and applied science courses contained in an engineering curriculum: Public speaking, elementary economics, social science, public utilities, commercial geography, agricultural economics, business contract and transportation law, industrial management, business organization and administration, salesmanship, money and credit, cost accounting, insurance, history and economics of commerce, marketing and distributing systems, markets and prices, economics of railroad transportation, shopwork in wood and metal, machine elements, mechanics of machinery, fundamentals of gas and other engines, and electrical engineering, including ignition, starting, and lighting.

The highway transport engineer or manager also should have knowledge of all of the following special subjects: American and English highway transport methods; American and English highway traffic legislation and regulations; interrelationship of highway, railway, and waterway transport; highway transport surveys; highway transport management; costs and record systems; fundamentals of highway engineering affecting economic highway transport; and mechanism, operation, and maintenance of motor trucks, tractors, and trailers.

Highway transport engineering courses may be offered by technical institutions by utilizing several educational agencies.

First, the courses may constitute a fourth-year option in the civil, mechanical, or general collegiate curriculum. A review of the curricula of the three engineering courses mentioned indicates that 12 semester hours may be assigned in the fourth year to highway transport engineering without eliminating any fundamental engineering courses.

Second, a complete highway transport engineering curriculum may be arranged similar to the curricula of civil, mechanical, and electrical engineering courses. Such a course should include all of the humanistic, pure and applied science, business, engineering, and special courses previously enumerated. In this connection it should be pointed out that a four-year course devoted to highway transport engineering and highway engineering would provide an admirable foundation for men entering either field of engineering. Broadly trained highway engineers should have, in addition to the training in the fundamental humanistic, scientific, and technical courses, a knowledge of highway engineering, of the vehicles using highways, and of methods of highway transport.

Third, technical institutions may offer graduate engineering courses, which should be advanced specialized courses designed primarily for men who have taken a first degree in arts, science, or engineering, who have acquired a knowledge of the fundamental principles upon which such advanced courses are based, and who have had a certain amount of experience in engineering or highway transport work. It is evident that such courses should be given under such conditions that it will be practicable for engineers and others engaged in highway transport to take advantage of the opportunities offered. While the usual type of one-term or one-year graduate course may prove of value in some institutions, the writer is of the opinion, based on an experience with graduate courses for practicing engineers extending over a period of six years, that courses given in a concentrated form in short periods constitute the most efficient method of meeting the demand of practicing engineers for advanced technical training.

As a definite indication of the demand for such courses, it is of interest to note that during a period of five years there were 229 registrations in the graduate course in highway engineering at Columbia University, in which all subjects were given in periods of from two to three weeks. As far as amount and character of educational work are concerned, the 16 short-period courses which were previously given at Columbia University under the direction of the writer fulfilled the requirements for the degree of master of science. Columbia requires that each candidate for the master's degree shall

be in residence for one collegiate year or eight months. Candidates for the master's degree in the graduate course in highway engineering fulfilled the requirement in one of three ways: First, by being in residence for one collegiate year, or from October to May, inclusive; second, by being in residence for two winter periods from December to March, inclusive; and, third, by the distribution of residence over several years by being in attendance for parts of three or more winter periods. Columbia further requires that each candidate for a higher degree must hold a baccalaureate or engineering degree from an approved institution.

In considering the development of graduate short-period courses, it is of interest to note the details of the records for registration for the 1915–16 session at Columbia. Twenty-seven American universities were represented by their graduates. The 50 men registered as graduate students were connected with the following fields of work:

State highway departments	8
County highway departments	5
Municipal highway departments	15
Consulting engineers' offices	6
Contractors' engineering organizations	11
University faculties	1
Engineering departments of companies manufacturing road and paving machinery	3
Engineering, research, and chemical departments of companies manufacturing road and paving materials	1

The widespread interest in this graduate course is shown by the following résumé of the localities from which the graduate students came at the time of their registration for the 1915–16 session: Denmark, New Zealand, Uruguay, Canada, Oklahoma, Connecticut, Massachusetts, New Jersey, Pennsylvania, New York, North Carolina, Texas, Oregon, Maine, Georgia, Louisiana, and Nebraska. It is of interest, as giving an indication of the character and maturity of the graduate students, to note that the ages of the men varied from 22 to 45 years, and that several of them, at the time of entrance upon the graduate course, were receiving salaries of $3,000 to $5,000.

At the University of Michigan, graduate work in highway engineering and highway transport, leading to the degree of master of science or master of science in engineering, has been arranged especially for men engaged in the practice of highway engineering and highway transport. Eighteen graduate short-period courses in the above subjects will be given during the months of December, 1920, to March, 1921, inclusive. Each course will consist of 30 lectures and will be given in a period of two weeks, and will count as two hours' credit toward the total of 24 hours required for the master's degree. This plan will afford highway engineers, chemists, contractors, engineer-salesmen, highway transport engineers and man-

agers, motor-truck salesmen, and others interested in highway engineering and highway transport an opportunity to obtain advanced knowledge during the season of the year when leaves of absence may be easily obtained. These courses are open to graduate students and qualified special students. As indicative of the scope and content of the courses in highway transport, the following descriptions are given:

Highway transport surveys.—This course covers the subject of traffic classification and census, weights, speeds and dimensions of vehicles, highway factors affecting economic highway transport, investigations of highway routes, transport legislation and regulations, rural and urban transportation opportunities and competing carriers, including railways and waterway transport facilities.

American and English highway traffic legislation and regulations.—Legislation pertaining to weights, dimensions, and speeds of motor trucks, tractors, trailers, and motor buses; franchises for highway transport routes; rate legislation; national, State, county, township, and municipal laws, licenses, taxes, and traffic regulations.

Interrelationship of highway, railway, and waterway transport.—Development of highway, railway, and waterway transportation; economic comparison of methods of transport of passengers and commodities; characteristics and efficiency of each type of transportation; influencing factors of distances, haulage, rates, kinds of freight, packing, equipment, and port, terminal, and warehouse facilities.

American and English highway transport methods.—History of American and English highway transportation methods; comparison of horse and motor transport; municipal haulage, municipal delivery systems, store-door delivery, intercity haulage, long and short haulage outside of cities, rural motor express, return-loads bureaus, motor-truck parcel post, plant and factory haulage, Army transport methods, horse transportation methods; efficient methods of packing, handling, loading, and unloading raw and manufactured materials.

Highway transport management, costs, and record systems.—Fundamentals of efficient management of the different highway transport methods; administration and organization of transportation companies; cost and record systems; elements of cost of operation of motor vehicles, including direct, overhead, and lost time charges; relation of highway to operating cost.

Highway transport seminary.—Library research, and preparation and presentation of reports, papers, and briefs. Assigned work on special problems relating especially to such subjects as highway transport economics; interrelationship of highway transport, good roads, and rural development; consumers' organizations; community schools and motor buses; effect of roadways on vehicles.

Mechanism, operation, and maintenance of motor trucks, tractors, and trailers.—Engines, including operating cycles, valves and valve timing, carburetion, ignition systems, oiling systems, cooling, rating, and characteristic curves; clutches; transmission and drive shafts; rear axles and differentials; front axles and steering mechanism; brakes and springs; engine and truck testing and performance curves; truck operation and control; truck maintenance.

While advocating the introduction of undergraduate and graduate courses in highway transport engineering, the writer wishes to place himself on record as opposed to educational institutions offering such

courses unless their financial resources are such that they can secure specialists to give such courses and provide the necessary laboratory and field equipment. Also it should be emphasized that duplication of specialized courses in institutions located in the same geographical section of the country should be avoided. If this recommendation were universally adopted, educational resources could be conserved with resulting economy and material increase in the efficiency of specialized courses. It is believed that the high cost of the necessities of life, with the resulting demand that salaries of educators be materially increased, will force many institutions to seriously review their educational programs and to determine the fields in which they can best serve their communities and most efficiently fulfill their mission in the Nation's educational system.

PREPARATION OF MEN FOR SERVICE DEPARTMENTS.

Discussion by H. R. Cobleigh, Secretary, Service Division, National Automobile Chamber of Commerce.

With most articles of trade, once they are sold and pass into the hands of the user, the makers and sellers cease to be concerned. This is not true of automobiles. The manufacturer of a car is the creator of a responsibility. Throughout the useful life of the machine the owner is dependent upon the manufacturer directly or through the dealer for parts to replace those that wear out or are broken, and upon the dealer or independent repair shops for overhauls and repair work. This, commonly known as service, therefore constitutes a third branch of the industry, in addition to the two common to other lines, manufacture and sales. You have heard from others the needs in the way of education for factory and dealer personnel. It will be my purpose to set forth something of the need for the education of men to carry out the important task of servicing the ever-increasing number of motor vehicles.

On December 31, 1919, there were 7,558,848 motor vehicles registered in the United States, of which about 90 per cent were passenger cars and 10 per cent motor trucks. Exact figures are not yet available as to the number of men now employed in repair shops. Such figures have been collected in the recent census, but have not yet been tabulated. These will show the number in each of the various classes of occupation, such as service managers, testers, stock-room men, service salesmen, superintendents, foremen, mechanics, helpers, and laborers. For our purposes we may sufficiently closely estimate the total number now employed. There are reported to be 43,643 repair shops in

the country. Assuming that the average number of men employed in each shop is five, a conservative estimate, for while the largest shops employ upward of a hundred men, the smallest have at least three, this would mean that 218,000 men are now employed in service work. Dividing this number into the total number of cars in use, we have about 35 cars to each man. Based on the rate of increase in number of cars registered each year, the probable number in use two years from now will be 12,000,000, and to service these, at the rate above arrived at, there will be needed 342,000 men, or 124,000 more than at present. Supposing that 10 per cent of the men now employed will be lost to the industry within two years by death, change of occupation, or other cause, there will be needed 22,000 new men to replace this loss, or a total of new personnel of 146,000 to be fitted for the various positions in the next two years. How well fitted they will be will depend on what measures are taken to educate them.

At present we are far from having sufficient efficient help. There is not only a lack of enough men, but many of the men now employed are perforce used because of want of better men. Probably our average is not above 50 per cent efficient. While 100 per cent is not attainable, by proper education we should be able to raise the standard of efficiency to at least 75 or 80 per cent. A college or engineering school education may not be essential to any considerable part of these men, but would be advantageous to the small percentage who fill the more responsible executive positions. General education comparing to graduation from high school would be necessary for a larger share of these men, as well as special training along lines of business or accountancy. The great bulk, however, are those needing vocational training fitting them as mechanics and for which the industry must look to the automobile schools, Y. M. C. A. courses, manual training high schools, and other institutions giving courses in mechanical trades. The further this preliminary education goes, the less it will be necessary to teach the men after they take up their work in the shops before they become of real use.

Less and less as time goes on will the higher executive positions be filled by men promoted from the ranks. Graduate engineers will find this field sufficiently attractive to enter it, and service as we know it to-day will take on a new standard. Indeed, it must for the continued prosperity of the industry. It is common knowledge that present-day service is far from what it should be. There is vast room for improvement, and this improvement is bound to come. The public demands it and the industry appreciates its necessity. The latter fact is attested by the interest that is being shown in service as evidenced by the recent creation of the service department in the National Automobile Chamber of Commerce. The engineering problems relating to design and manufacture that have

so far engaged the makers are relatively near solution as compared with those involved in maintenance of the equipment on the road, and the latter problems will be those that in the next stage of our development will occupy the attention of the industry.

We must contrive ways and means for performing work in the service stations and repair shops that approach more nearly to the methods obtaining in the factories. If cars were built as inefficiently as they are overhauled, they would cost about four times as much as they do. Conversely, if they could be overhauled as efficiently as they are built, the work could be done for a quarter its present cost. While this ideal may not be attainable, certainly much can be done by concentrating the work in fewer larger shops, so that the volume of work handled would justify the installation of labor-saving machinery and the employment of processes that small shops can not afford. At the same time the employees, by specializing on the different operations performed, would become so expert that the labor costs would be greatly reduced. If the smaller shops would confine themselves to minor repairs and adjustments, sending units requiring rebuilding or overhauling to these specializing plants, the work could be done better, quicker, at half the cost to the owner, and with equal profit to the individual shops than is possible while the little shops attempt to do it all with inadequate equipment and less experienced help. Herein lies a practically untouched field of wonderful opportunity in which engineering talent might accomplish a great work along lines of more efficient organization, shop layout and equipment, motion and time study, special tools, training of operatives, etc.

Another evidence of the new attitude of increased interest in service is the number of service associations springing up all over the country, all of which have as one of the main purposes of their organization the promotion of means for educating the personnel to man the service stations and repair shops. The best brains are being attracted to this problem and results are bound to come. It will need men of engineering training to work out the methods and systems and a whole army of skilled mechanics to carry out the work.

I will not attempt to go into details as to what the mechanics' training should be. Opinions differ, but there are plenty who have studied the requirements who are ready to lay out curricula for the schools. The crying need is for more schools and instructors and better courses in existing schools. As a rule, the courses as so far provided do not go far enough. Obviously, skilled mechanics can not be turned out in six to eight weeks. An obstacle in the way of extending the period of instruction is the unwillingness of the students to spend enough time in school. Much must be done

through publicity to inform the youth entering this calling that they must be prepared to devote longer time to their preliminary education. The future employers of these men stand ready to help them overcome the hardship of a prolonged nonearning period by cooperating with the schools so that the students may divide their time between the shops and the schools, letting them get the theory in the schools and apply it in the shops to get the practice, so that they may be earning something while continuing their education.

In a nutshell the situation is this. The industry has grown at a rate that has outdistanced its ability to develop for itself enough competent men of all grades to fill the places open to them. A negligible portion of the men now carrying it on contemplated entering it when they were in school. In other words, nearly all were educated for their present work within the industry. It is becoming increasingly difficult to continue to do this. Just here I should like to mention that to which I ascribe the shortage of college-trained engineers throughout the automotive industry. It is this, that fathers with sons to educate and sons considering what lines of study they will pursue so far have had little appreciation of the possible future for them in this industry. Twenty years ago the field of great promise was electrical engineering, and boys of mechanical bent were advised on every hand to make this their life work. Before that civil, mechanical, and mining engineering attracted the ambitious youth, unless their proclivities inclined them to the still older professions of medicine, the ministry, or law. Since then chemistry has had its turn as the popular lure. Now it is high time that our second largest manufacturing industry be held up as a deserving goal for the rising generation.

So we turn to the educators for their assistance. We submit that we have an industry meriting their keenest consideration. We look to them to direct the attention of those coming to them for instruction to the worthiness of this field for their future activity and to offer them those subjects that will best fit them to enter upon careers in the automotive industry.

So much stress has been laid on the need of men of advanced training that I would impress as my last thought that no army is composed entirely of officers. Privates in the ranks are needed, 20 or more to every officer, so, from the service point of view, we are asking what can the education do to give us more real mechanics so that we may decrease the cost of car maintenance and give the public the service to which it is entitled?

EDUCATION OF SALES ENGINEERS, FLEET MANAGERS, MECHANICS, ETC.

Discussion by F. W. Davis, Consulting Engineer, The Pierce-Arrow Motor Car Co.

These remarks will refer mainly to the requirements and training of men in transport engineering as bearing on the operation of fleets and trucks, of men qualified to take care of maintenance, of shop foremen, of trained mechanics, of men who are sales engineers, and of men who can go out and present the transportation problem in an intelligent manner.

The company with which I am connected has found a great need for men in the transportation and service end, and we have conducted, in the past two or three years, courses at the factory where we have taken a certain number of men, in some cases men having had technical training and in some cases men who are mechanics and who have been in the factory and whom we have found suited to advancement in a particular field. We have given such men a short, condensed course of three months, covering both lectures and mechanical work in the factory. We thus fit them to go out as sales engineers, transportation engineers, and men who can take executive positions in the operation of transportation departments. That covers the transportation end; then the other end is the service function, which has to do with the shop foreman, fleet managers, inspectors, and highly trained mechanics. The number of men we take into that are about equal to the others. That course extends over about six months. These men have had very considerable practical experience up to that period. They are in every sense mechanics, not necessarily skilled in all branches. We put these men through this six months' course and at the end of that time they are able to go out and take actual charge of our so-called agents' shops. They are able to take over the handling of large fleets; they are able to fill the position of inspector, which is also highly important, and bears a very definite relation to the so-called locomotive inspector. The others are the trained mechanics, who are able to handle the work which comes to the repair shops. We can put 50 men per year in the transportation branch per 5,000 vehicles and an equal number of 50 men in the service end per 5,000 vehicles.

The Society of Automotive Engineers has recently formed a committee, of which I am a member, for actually looking into what we call the science of truck operation. It is an attempt to formulate certain underlying economic principles bearing on highway motor transportation in comparison with railway, waterway, and horse trans-

portation, and in that way to develop certain material, collect statistics, and to make available for our use, not only in the small endeavor that we have undertaken in our plants, but also more or less to give out to those technical colleges which are going into this subject of highway transport engineering. So much for the actual acquiring of that information. The information at the present time is more or less scattered. It is in the hands of a few, but the Society of Automotive Engineers and the manufacturers will be very willing not only to lend their time and their best efforts to collecting and tabulating this information, but when it is available and when the courses are mapped out in the colleges, men from the companies and from the society will be very glad to volunteer, certainly at the start, and possibly for more or less continuation, in order to go before the various technical colleges and present this material. That is, they will be willing to volunteer, to a more or less degree, to conduct some of the courses in transport engineering, not because instructors are not able to handle it, but because the information is so vague and scattered that it is not available for the average college instructor to secure himself. The Society of Automotive Engineers is going to take the material which is collected and print it in some form and thus make it available for anyone who may want to use it.

QUALIFICATIONS OF HIGHWAY TRANSPORT ENGINEERS.

Discussion by ERNEST FARR, Chief, Firestone Ship-by Truck Bureau.

In submitting the following suggestions we desire to explain the source of our information and the methods by which it was obtained. It is based on the experience of more than 100 men, operating Firestone Ship by Truck Bureaus in 65 different districts throughout the country and devoting their entire time to the collection and dissemination of information on motorized transport. The statistics come from the research division of the Firestone Ship by Truck Bureau, which is engaged exclusively in collecting and correlating information on highway and transport conditions for the use of the general public.

This bureau has been in active operation for more than a year. It keeps up-to-date information on approximately 2,000 highway routes between cities and into rural districts. These routes cover about 20,000 villages and towns. Listed with these bureaus are more than 6,000 truck operators, either running on schedule between these towns or subject to call for special trips upon these routes.

One of the main objects of the bureau from its inception has been to train the managers of its various branch bureaus to become highway transport engineers. So we offer the following thoughts as the result of our practical experience along this line:

Qualifications.—To meet the needs of highway transport to-day a man must be trained not only in the fundamentals of practical roadbuilding, but also be mentally equipped to investigate and reach proper conclusions on motor transport, traffic, and highway problems of the particular community in which he may be located.

The economics of the motor car, its possibilities and limitations; the trend and direction of urban and suburban traffic, how to anticipate it and prepare to relieve congestion; the weight and volume of traffic and the type of highway that will be best suited to it; local geological conditions and the climate as they affect the construction and maintenance of roads must be a part of his training. Mechanical upkeep, operating economics, and types of motor vehicles and their adaptability are also among the subjects in which he must have special instruction.

The field.—The field for a man specially trained in highway transport engineering would include Federal, State, and county offices, and positions with large cities; industrial organizations operating big truck fleets; large motor service operators; truck manufacturers and distributing organizations; and ship by truck bureaus and organizations of a similar nature.

The future.—The growth of highway motor transport is limited only by the construction of good roads and the production of motor cars. That limit is not yet in sight. The trained highway transport engineer could create his own opportunities. His special training would command attention and direct public opinion to highway transport. Heretofore it has lacked proper and effective presentation to the public.

Public attention.—In order to bring a fuller understanding of the need for specially trained highway transport engineers it seems to be necessary to concentrate public opinion on the need of good roads, and educate the people on the transportation possibilities of the motor truck. The call for specially trained men will naturally follow.

The Firestone Ship by Truck Bureau has by demonstrations, national advertising, and various means of publicity, and especially by local application, been carrying on this work of education for more than a year.

Its bureau managers are supplied with information and statistics on the advantage of good roads and motor-truck service. News, instructive and interesting, has been supplied to the newspapers and magazines, showing just how highway transport has added to the

health, happiness and wealth of communities. Books and pamphlets, showing the advantages of ship by truck, giving advice to prospective motor car purchasers and outlining methods and costs of operation, are distributed. The policy behind this has been not to merely make sales for the manufacturer or improve any and all roads indiscriminately, but to put the whole highway transport business on a scientific and economic basis. Individuals or communities are not advised to invest in motor transport or good highways unless they will receive a continuous economic advantage by so doing.

General.—For example, the Firestone Ship by Truck Bureau has had applications from farmers' organizations, such as fruit growers' exchanges and cooperative associations, asking for solutions of their transportation problems. Should they purchase one truck, or half a dozen? What should the equipment be and where should the roads be improved? We sent a highway transportation expert into their districts. His work for a Michigan fruit growers' exchange is typical. He investigated and found that one 2-ton pneumatic-equipped truck and four trailers would serve the fruit growers in rush as well as in slow season and do it economically and with the smallest initial investment. He arrived at his conclusions by examining the roads, the location of the farmers to be served with respect to the community packing plant, the amount of fruits handled each day, and the maximum amount that their profits would permit them to invest. His recommendations were adopted with gratitude by the farmers and when put into operation will save them from 1 to 3 cents a crate in transportation charges. And the number of crates handled runs into thousands a month. That particular episode, it seems to us, might well be part of a college-trained highway transport engineer's job. There are thousands of groups of farmers and small shippers in this country awaiting accurate and truthful information on how to solve their transportation problems. The highway transport engineer with proper training can do it, not only to his own and the farmes' benefit, but to the great benefit of the whole community.

The automotive industry could use specialists in highway transport to great advantage. With their special training they could accurately define the needs of customers, thus giving greater service. This is also true of large fleet operators. Selection of the best routes, the type of equipment to meet particular needs and economizing in operation would fall within a highway transport engineer's duties with an organization operating many trucks.

As to specific recommendations on what changes ought to be made in present college courses, or whether an entirely new course ought to be offered, it seems to us that such a decision should be left in the hands of the educators. Here we are attempting to tell what kind of

training the industry can use. How schools and colleges can equip men to meet these needs can be worked out best by the educators themselves.

MOTOR TRUCK FLEET MANAGERS.

Discussion by CLYDE JENNINGS, Managing Editor, Automotive Industries.

In discussing the demand for motor-truck fleet managers, several men who have given this subject mature consideration have called my attention to the fact that the average cost of a truck is about $3,000, and that a person with five trucks has an investment of $15,000, and more than likely an additional investment of $15,000 in garage and equipment, making a total of $30,000 for the average fleet of five trucks. This investment naturally leads the owner to put a special man in charge. From the same authorities I learn that there are about 20,000 such fleets in this country. It is estimated that there will be an increase in these fleets of at least 5,000 within a year. It is presumed that the increase will be heavier in subsequent years.

With a fleet of ten 5-ton trucks, costing on an average $6,000 each, and an additional investment, including turnover of tires and so forth, of an equal amount, the total investment would be $120,000 a year, without counting the cost of a garage. It has been suggested that a fleet of the size I have mentioned would need a transportation manager as a general director; a delivery superintendent to see that all trucks were properly loaded; a maintenance superintendent in charge of the garage and all repair work; an operation superintendent in charge of the drivers and the routing; and a cost accountant to collect and compile analyses of truck costs. All of these men would need special motor-transport training. A managerial personnel of this character would suffice to govern almost any sized fleet, but as the fleet grew the various superintendents would begin to require assistants. It is as yet an unanswered question as to the number of specially trained men who would be needed as the fleets grew larger.

EDUCATION FOR HIGHWAY TRANSPORTATION WORK.

Discussion by LEE LAMAR ROBINSON, Transportation Section, Council of National Defense.

One of the outstanding features of this movement, as I see it, will be its psychological results. Groups, large or small, ranging from the youthful helper on the motor express truck or in the repair shop

of the service station to the college student and the young engineer, discussing the benefits of a two or four or nine weeks' course, as the case may be, will almost certainly grow enthusiastic over the opportunities offered, and will desire to take advantage of such opportunities. Like the endless chain, each worker whether he be on the truck, in the shop, or with a leveling instrument on the highway, who has taken some one of the courses, will want to tell his fellows what he is doing in an educational way, and will manifest a natural pride in his accomplishments. In this way the demand for opportunities to participate in some of the courses under consideration at our conference will spread almost without limit.

The courses suggested in our conference will not only be of economic value to the Nation, but prove of great utility in time of war.

A great thirst for knowledge has been manifested since the war, such as was never known before in this country. Records of all colleges will bear out this statement. We must not forget that the highway engineers of to-morrow are the boys in the public and preparatory schools and the colleges of to-day. In view of this fact, the extension of the manual training idea to take in a primary course in civil engineering should not be postponed in the schools. This course should include, for example, something on construction and maintenance of highways, and mechanical engineering, including the building, maintenance, and operation of the machine traveling over the highways.

Instruction in safety measures on highways should be given to children in the various schools. Working with men of experience, I was able, in connection with my duties in the Council of National Defense, to aid in drafting regulations and directions regarding the subject, and also, to sound the sentiment of the country regarding the same. It should be comparatively easy, in view of the sympathy of the public and of school directors and teachers in this movement, to map out a program under which instruction of this character could be made a definite part of the work in the public schools.

The Council of National Defense has made a survey of highway and highway transport conditions throughout the entire world, with the result that information of almost inestimable value has been compiled. A digest of the returns received from probably 74 United States consular districts throughout the world should also be of value.

ECONOMICS OF HIGHWAY TRANSPORT.

By R. C. HARGREAVES, District Manager of the Goodrich Tire & Rubber Co., Detroit, Mich., and Vice President National Highway Traffic Association.[1]

The invention and distribution of automotive vehicles suitable for transport have been followed by a great era of road building. The further development of highway transport and of highway construction will doubtless be controlled by the same economic forces which have been in operation during the past. By combining the vehicle and the properly established route we are enabled to develop not only one trade route but thousands of routes of trade influence and commerce within our shores. In the words of Senator Harding, transportation "is the one agency of putting every community in the Republic on the way of commercial progress."

The history of transportation shows that as new trade lines were brought into existence new trade centers were established. The prime motive back of these activities was commerce, the basis of all human progress. To-day "the constructive machinery of civilization and progress" is the automobile which meets a fundamental need of our modern life.

On account of the present lack of adequate highway transport facilities, a large number of our rural population are deprived of educational opportunities. Likewise, crowded cities are hurt by hunger on account of food shortage when proper highway transport might bring the food products from near-by acres without serious delay. Highway transport may also serve those who live in congested city quarters by offering more ideal living conditions in near-by villages. The tool for improving rural life in all its phases, and consequently the means of keeping the country sections from gradual depopulation, is an adequate system of highway transport.

Herbert Hoover has said: "The rural motor express development which aims to provide efficient transportation between rural areas and consuming centers and rail and water terminals is, I believe, in the line of progress, and will bear large returns to producer, consumer, and carrier," etc.

The following item quoted from an English journal is significant:

> The market towns of Newbury and Andover, which are 17 miles apart, have been linked up by motorbus, the opening of the new service being inaugurated one day last week. The two towns are poorly served in the matter of intercommunication and, as they are on different railway systems, the circuitous train journey occupies three hours. The motorbuses complete the journey in 50 minutes at a charge of 2s. 6d. as against the railway fare of 3s. The service is to be run every two hours, starting and ending at 8 o'clock, morning and evening.

[1] From an address made before the annual meeting of the Michigan State Good Roads Association. 1920.

Now, consider for a moment the case of two towns, and call them Tyre and Sidon. For the towns I have in mind are as inconspicuous to-day as those of the same name in the old world were before transportation made them famous as trade centers. With highway transport available, a trade route would be established between the two, and these towns would in time become established as trade centers. Assume that it were possible to establish any one of three routes between these two towns, what direction would it take and how about its profile? Without a scientific study of the possible trade development along the route, the efforts of the ablest engineer would be unsatisfactory. How much expense is justified in shortening the distance of the route 2 miles—reducing the grades one-half—eliminating curves—and in providing the most efficient type of road surface? What of the width now, and in 10 years; of snow removal to permit brisk trade 365 days in the year; or a snow embargo preventing a proper range of industrial activity to enter the trade centers, which activity would be dependent on 365-day roads?

These are a few of the problems—there are yet many more. And all of these problems I think of and study over as being included in this subject, "Economics of highway transport." And are these not even greater problems than the ones of construction we are usually battling with? True, we may know little about the bearing power of soils or the action of clay with or without water in suspense. But I believe we will know a great deal of such matters before we really make a start with the larger economic problems, because one is of the type that can be taken into the physical and chemical laboratory and expressed in the form of mathematical equations, and the other takes one into the laboratory of human life and experience and involves the personal equation.

In the future a tremendous growth and strengthening of the towns and villages of our land will doubtless take place. Even from the standpoint of foreign trade alone, it is the people of the towns and small cities in the country who should be vitally interested. For only consider that in 1919 $3,500,000,000 of foreign trade—about 45 per cent of it—was made up of fruits, cereals, vegetables, meats, eggs, and butter. This means a great deal to the towns and villages. And from the standpoint of manufactured articles, consider that it has been stated that over 50 per cent of the manufactured goods that go to buyers outside of the United States are produced in towns having a population of 50,000 or less. Imagine, then, countless villages and towns linked up by trade routes, growing steadily as trade centers, looking up in turn to the more natural centers of larger trade influences. At such points highway transport will be joined to our great steam and electric-rail system.

Hand in hand they must go, articulating perfectly. Rail transportation as the great roughing-out tool, used for first entering the heart of a country, and large section and highway transport as the light finishing tool for shaping the rapid improvement and development of the large tributary areas. What promise there is ahead in this country of ours. Arteries of commerce. Webster says of an artery, that it is a vessel carrying blood from the heart and a continual channel of communication. This, then, is the challenge laid at our door. To pick up the tool—highway transport—and apply it properly; to build arteries of commerce with channels uninterrupted despite rains and snow, so that commerce, the very life blood of our Nation, may flow with more certainty back and forth from ports to big cities, and on through to the towns and villages of our land, the very heart of our country.

RESOLUTIONS OF THE CONFERENCE COMMITTEE ON HIGHWAY TRANSPORTATION EDUCATION,

ADOPTED MAY 15, 1920.

Whereas the phenomenal development of highway transportation in the United States has created a demand for men having knowledge of and training in a new technical field, which may be designated highway transport engineering, and which deals with the science, art, economics, and business of transporation of passengers and commodities over highways; and

Whereas the manufacturers and users of motor trucks, in this conference assembled, have stated, first, that four thousand men should be trained in highway transport each year in universities for positions of motor-truck fleet managers, sales engineers, advertisers, business administrators, and highway transport engineers; second, that short-period advanced courses efficiently provide opportunities for men occupying the positions enumerated to obtain a knowledge and training in highway transport; third, that students in universities may be trained for the above-mentioned positions through the medium of four-year courses in highway transport engineering or group options in collegiate or technical courses; fourth, that one thousand automotive engineers, required each year for research and design positions, may be trained through the medium of four-year mechanical engineering courses which include automotive engineering options; fifth, the training of two hundred and fifty thousand men, required each year for the positions of shop foremen, skilled mechanics, inspectors, and motor truck operators, may be efficiently given by vocational automobile and factory schools; and

Whereas the need is daily emphasized in every highway department throughout the land of highway transport engineers, whose sole activity shall be the practical application of highway statistics and service tests so far as the same are valuable not only in the regulation of traffic, but to the scientific design and operation of highways and motor vehicles: Therefore be it

Resolved, That this conference strongly recommends that universities and colleges offer courses in highway transport as their facilities will permit, and

that at least 10 universities, located in different geographical sections of the United States, offer short period advanced courses covering the various phases of highway transport, and four-year courses in highway transport engineering or highway transport options in four-year collegiate or technical courses.

Whereas the fundamentals underlying the ideals and accomplishments of to-morrow must be implanted in the hearts and minds of school boys and girls of to-day; and

Whereas the avenues of transportation have carried civilization around the world and administered to the wants and comforts of all: Therefore be it

Resolved, That the underlying principles of highways and highway transport, as well as the rules of the road, be taught in the grammar schools and high schools of the Nation; and

Whereas it is desirable that those boys and girls who are naturally best fitted to carry on this most important work be selected scientifically and carefully with a view of the widest possible advantage to the Nation: Therefore be it

Further resolved, That vocational guidance be given in every grammar and high school in the land with a view of particularly selecting for all professions and activities, and particularly with reference to highway transport, those boys and girls who show unusual proficiency and appreciation of the vast problems of highway engineering and highway transportation.

A. H. BLANCHARD, *Secretary,*
Professor of Highway Engineering and Highway Transport, U. of Michigan.
EMORY R. JOHNSON, *Associate,*
Dean, Wharton School of Finance and Commerce, University of Pennsylvania.
JOHN WEBER, *Associate,*
Associate Professor of Mechanical Engineering, University of Pittsburgh.

THE CONFERENCE COMMITTEE ON BUSINESS EDUCATION AND HIGHWAY ENGINEERING AND TECHNICAL RESEARCH.

Chairman, A. F. Woods, president, University of Maryland.
Secretary, George F. Zook, specialist in higher education, United States Bureau of Education.

PERSONNEL.

R. D. Chapin, president, Hudson Motor Car Co.
H. R. Cobleigh, secretary, service division, National Automobile Chamber of Commerce.
H. W. Davis, consulting engineer, Society of Automotive Engineers.
A. T. Goldbeck, Bureau of Public Roads, Department of Interior, Washington, D. C.
M. L. Hemingway, manager, Motor Accessories Manufacturers' Association.
L. J. Hewes, inspector of roads, Oregon.
Charles S. Howe, president, Case School of Applied Science, Cleveland, Ohio.
Prevost Hubbard, Asphalt Association, New York.
C. D. Jarvis, specialist in agricultural education, Bureau of Education, Department of Interior, Washington, D. C.
Pyke Johnson, National Automobile Chamber of Commerce, Washington, D. C.
W. V. Logan, United States Tire Co.
G. F. Zook, specialist in higher education, Bureau of Education, Department of Interior, Washington, D. C.

EDUCATIONAL SUBCOMMITTEE.
CHARLES S. HOWE, chairman.
A. T. GOLDBECK, associate.
GEORGE F. ZOOK, secretary.

REPORT OF THE EDUCATIONAL COMMITTEE OF THE CONFERENCE SECTION ON BUSINESS EDUCATION AND HIGHWAY AND TECHNICAL ENGINEERING.

The conference committee had under consideration the problem of research in highway engineering and in technical engineering. It also considered the question of business education as a preparation for persons who might be employed in the automotive industries.

1. *Research.*—The committee first considered the question of research in highway engineering. It developed at once that research in the problems of highway engineering is an extremely important matter. Large sums of money have already been appropriated by the National and State Governments for the purpose of building

highways. As yet, however, many of the problems concerning the proper construction of highways remain unsolved, and before we may expect to build highways that will stand up under the new traffic conditions it will be necessary through research to determine how these highways should be built. At present only a very small portion of the sums appropriated for the building of highways may be used for research. Research is necessary not only to determine the character of the construction of roads according to the type of traffic that passes over them, but also to discover the kind of highways which should be built to withstand the climatic conditions in the several parts of the country. For instance, highways in the Southern States probably need to be of extremely different character from those which are built in the Northern States.

In the field of technical engineering, connected particularly with the automotive industries, it developed that the stimulation of research was not so necessary. For a long time research has been going on in the field of design and fuel in the automotive industry, and this work is still being carried on sufficiently.

The new field of research in highway transportation economics needs serious attention in the future. It is, for instance, a great problem to determine what is the cost of transportation by motor trucks and to what extent motor trucks should be used to replace other forms of transportation. It was agreed, however, that this research could be attempted only in the automotive industries themselves. On the other hand, it is highly desirable that colleges and universities train men in the methods of research who could later be employed in this field by the automotive industries.

One of the important problems which presented itself was that of coordinating the research in highway engineering problems at the various colleges and universities. Some colleges and universities are much better able to undertake the solution of those problems which concern that section of the country in which it is located. It was suggested, therefore, that there should be as much coordination as possible in the research in highway engineering problems which it is hoped will be conducted at the various institutions of higher learning. Mention was made of the admirable work of the National Research Council in attempting to stimulate and coordinate research work in all fields. It was the unanimous opinion of the committee that there should be some central body to stimulate and supervise research in highway engineering and transportation problems throughout the various colleges and universities which were in a position to undertake this research.

2. *Business education.*—The discussion of business education revealed the wide opportunities which there are in this field to add to the efficiency of the automotive industries. It developed that it was

highly desirable for a large portion of the persons connected with the automotive industries to have an adequate preparation in business courses which would enable them to undertake managerial positions, where they would be able to coordinate the work of the various branches of the industry.

In the discussion of this topic it appeared that much work of a valuable nature could be undertaken even in the elementary and secondary schools, where students could be taught elementary business forms and practices, which in time would assist them to accept positions of responsibility in industries.

In the colleges and universities it was pointed out that three fields of opportunity are open for a greater number of business courses. It has now become generally recognized that graduates of engineering schools are much more valuable to an industry when they are acquainted with those fields of business education which will enable them to coordinate the work of the various departments of an industry. Recently also there have been established a number of schools of business and commerce, whose graduates may find ample opportunity to accept important positions in the industries. It was suggested that students in liberal arts courses should be given an opportunity to pursue a number of courses in business and commerce and also in engineering, in order that they may be able to undertake important positions in the industries. Graduates of business courses and of courses in arts and sciences may be used in considerable numbers in industries that are generally regarded as technical in nature.

RESOLUTIONS OF THE COMMITTEE ON RESEARCH AND BUSINESS EDUCATION.

In view of the fact that a large volume of materials formerly transported by railroads is now carried over the highways, resulting in a great increase in weight and volume of freight carried by motor trucks, and in view of the lack of knowledge concerning many of the fundamentals of highway construction to take care of this traffic, and in view of the enormous sums now being expended and to be expended in the future for road construction, it is the sense of this conference:

1. That research in highway engineering and highway transportation problems is necessary to secure highways capable of carrying the traffic which will pass over them in the future.

2. That a moderate number of colleges and universities properly equipped and located in various sections of the country should be urged to undertake research in highway engineering and highway transportation for the purpose of training undergraduates in the methods of research and solving the problems of highway engineering through competent graduate research.

3. That this research should be directed by some central authority, which should have power to call to its assistance other agencies and organizations capable of giving advice on this subject.

4. That sufficient funds should be raised and placed in charge of this central body to carry on this research.

5. That this central body should have the power to invite the cooperation of State highway departments, of colleges and universities and experiment stations, and to assign to these cooperative agencies funds for the prosecution of this research, and to supervise and direct the conduct of the work.

6. That in addition to these funds the National Government be urged to appropriate generous funds for research in highway engineering and highway transportation, and that each State set aside a definite portion of the funds appropriated for highway construction for the prosecution of research in highway engineering and transportation.

7. That the State highway departments should, wherever possible, seek the cooperation of colleges and universities and experiment stations in solving research problems in highway engineering peculiar to the State concerned.

RESOLUTIONS REGARDING BUSINESS EDUCATION.

1. That the largest possible opportunity be given to students in the elementary and secondary schools to learn simple business forms and practice, bookkeeping, commercial law, elementary banking, and elementary practical economics in order that this training, together with practical experience, may enable them to advance into positions of responsibility in the industries.

2. That the conference indorse the idea of a liberal opportunity for engineering students to take courses in business education which will train them for managerial positions in the industries.

3. That the conference favors the establishment of schools of business and commerce in which students, in addition to numerous courses in business and commercial economics, may secure such technical and general training as will fit them for leadership in industry.

4. That the colleges of arts and sciences encourage the placing of courses in business economics on a par with humanities in order that graduates of these colleges may take their places in industries speedily and intelligently.

CHARLES S. HOWE, *Chairman,*
President Case School of Applied Science.
A. T. GOLDBECK,
Bureau of Public Roads.
GEORGE F. ZOOK, *Secretary,*
Bureau of Education.

PROCEEDINGS OF THE CONFERENCE COMMITTEE ON BUSINESS EDUCATION AND HIGHWAY ENGINEERING AND TECHNICAL RESEARCH.

Chairman: Dr. A. F. WOODS.

CHAIRMAN. I believe that it is unnecessary to make any opening statement as to our discussion this afternoon. I understand that we should discuss the subjects of business education and highway engineering and technical research in their relations to the general problem outlined in the morning session. Certain gentlemen have been requested to open the discussion of these subjects, beginning with the consideration of highway-engineering research. Mr. Goldbeck will open the discussion.

Mr. GOLDBECK. Before approaching the subject of research in highway-engineering courses, it will be well to stop and consider the object of research work as undertaken in colleges. Primarily every subject in engineering courses should be studied for the purpose of mental training or to add to the general or special knowledge of the student so that he will be better fitted for carrying on his life's work, and it is highly desirable that such research work as may be undertaken will at least aid in serving this purpose. Undergraduate research, first and foremost, should be of benefit to the student. So far as benefit to the highway-engineering profession is concerned, it may be said that research work in engineering colleges should be conducted with this in view, but that this purpose should be regarded merely as of secondary importance.

Highway engineering and highway transport are still in their infancy, and there are numerous problems which must be solved before we shall have attained that degree of perfection in the art of road building and highway transportation so greatly to be desired. These problems, in the main, can be solved only by thorough and conscientious study and research in the field and in the laboratory. Many of them are far too big to be undertaken in the short time allotted to thesis work in engineering courses, but nevertheless most of the major problems are capable of subdivision into minor problems requiring a comparatively short time to solve, and such problems when solved, assembled, and digested will give the answer to the big, main problems being studied.

Would it not be well to have these major problems thoroughly outlined by some suitable agency, such, for instance, as the engineering division of the National Research Council or by a committee of the American Association of State Highway Officials? Let these problems be subdivided into the minor sections requiring solution, and let the research work of the colleges be conducted toward the end that the solution of the minor sections of the big, main problems may be obtained. The statement of the problem in detail would be of great educational value to the student and would give him a clear conception of the goal to be attained. His interest in the solution of his part of the program would be stimulated by having the same problem assigned in several institutions, and in this way the various students or groups in the various institutions at work could compare their final results. They would be thus urged toward accurate observation and careful work. The very fact that groups in various colleges were working on the same problem would add to the value of the results obtained, since it could very readily be determined whether the results could be accepted as being of value or be rejected because of inconsistencies. It would be my idea that

some central body or committee in cooperation with the colleges could see that the problems were distributed to the various institutions so that there would not be too much duplication of effort. There should be some duplication, however, and the same problems should be repeated over several successive years. The results thus obtained might be of some value to the engineering profession.

The fact that the student is made to feel that he is cooperating in a big national research for the good of a common cause would be a great stimulus to him in his work, and the fact that he would be given an opportunity to compare final results with others working on the same problem would promote accuracy. The experience gained by the undergraduate in research would be splendid training for him and would aid in fitting him for more extensive and more useful researches to be undertaken in later life. It is believed that such a procedure in research in highway engineering courses primarily would benefit the student, and at the same time might add to the general fund of knowledge leading to the advancement of the science of highway engineering.

The most extended researches might be undertaken in graduate courses under the general supervision of the same advisory body, and it is to be expected that the results obtained from graduate researches would be of much more value to the profession than those from undergraduate work.

CHAIRMAN. One of the speakers this morning said that a committee of the engineering division of the National Research Council was undertaking a project of that kind.

Mr. GOLDBECK. Yes; I understand that is the case, and it seems to me that is the logical thing to do. I feel that in the first place we must have a very definite outline of the problems. The problems should be minutely outlined, and there should be some central body to see that they are properly distributed, considering the kind of equipment the colleges have. Those problems could then be worked out in detail. You can readily realize that it is impossible to assign any one great, big problem to students for research work, because they have not time enough to devote to such work, but the main problems can be subdivided and the students can work on the minor sections of the main problems.

CHAIRMAN. Would it be an advantage if engineering institutions should have connected with them research departments, such as the experiment stations of the agricultural colleges, similar to the agency planned in some of the bills now before Congress to conduct fundamental research and then to have these minor research problems more or less articulated with them?

Mr. GOLDBECK. That may be worked out in connection with advanced courses.

CHAIRMAN. Is it your idea to have students do research work in the first, second, and third years?

Mr. GOLDBECK. No; I should say not. It should not begin before the third or fourth year. I hardly believe the students are ready for research work before the beginning of their senior year.

CHAIRMAN. Ordinarily, for instance, in the agricultural colleges, the research work started in the senior year is of a minor nature, just enough to give them the training in methods of research rather than in the solution of problems.

Mr. GOLDBECK. I feel that all these problems must necessarily be of a minor nature. I do not feel that research work as conducted in the colleges in the time allowed for such work can be anything else but of a minor nature. It is important work, but I think the minor problems, when assembled, will give the answer to the big main problems.

CHAIRMAN. Your remarks are directed more to the training of the students than to the solution of research problems in connection with highway construction. That, you think, is the most important aspect of the case?

Mr. GOLDBECK. I feel that is what the student is going to college for, and not primarily to conduct research. Any research work that is conducted should be given for the purpose of training the student.

CHAIRMAN. I wonder whether we are expected to consider also the importance of fundamental research. While perhaps not connected with the educational aspects directly, there is a field there, connected with the field of highway engineering, to which attention ought to be called. I should judge that the engineering division of the National Research Council must feel that necessity, inasmuch as it has established a committee on highway engineering research, which will, I suppose, be devoted mainly to the fundamental aspects of the subject. You are in that group. Do you know what the feeling of the committee is?

Mr. GOLDBECK. As I understand the outline of that group, the engineering division, as far as highway engineering is concerned, is divided into three main sections: (1) Road design; (2) economics; (3) highway transport.

Dr. ZOOK. Is it the idea of the Research Council that research work can be done in connection with the usual work of the fourth-year student, or is it that graduate work should be developed?

Mr. GOLDBECK. I do not believe the committees of the National Research Council are depending upon the little research work done by students. They are going to depend primarily on research work done in graduate schools, or by various State laboratories, or work

done by committees of the various technical societies. They are not going to depend very much on the work of undergraduates.

CHAIRMAN. They have definitely approved the legislation to establish research experimental stations in connection with colleges and universities?

Mr. GOLDBECK. The National Research Council has taken the attitude that there are two aspects of research work: (1) The development of research personnel, which must start back in the finding of individuals adapted to research, and train them for research; (2) the solution of fundamental problems by direct effort, and the development of research agencies in view of finance, and manned by thoroughly experienced research men.

Mr. CHAPIN. There has been research work carried on in highway construction on the part of students at the University of Michigan, and divided into permanent and temporary research, and they have endeavored over a period of years to develop as much student research work as can be done, and that type of work is directly stimulated by scholarships, and has proven to be very successful to the State of Michigan.

Mr. HUBBARD. Is that work undertaken by undergraduates?

Mr. CHAPIN. Yes; by undergraduate students.

CHAIRMAN. Do you know whether the State highway departments or industries provide any scholarships?

Mr. CHAPIN. I am providing one myself.

CHAIRMAN. You are doing it as an educational proposition rather than to get some fundamental results?

Mr. CHAPIN. I gave a scholarship, or, rather, I should say a fellowship, in highway engineering at the University of Michigan; they were able to get together more or less in the way of equipment. The fellowship which I gave is based on permanent types of highway research work along that line. The Detroit Edison Co., while I have not investigated it, have over the same period of time given a fellowship based on the investigation of dirt roads, possibly because they have in Michigan investments scattered all over the State and they want information to tie up their various plants with some sort of highways. They have continued to do that, and it is an annual scholarship.

Mr. HUBBARD. I should like to raise the question as to whether research work should find a place in undergraduate work? Personally, I do not think it should, unless the usual procedure of introducing highway engineering at the present time is changed. It is introduced usually in the senior year, and in order to get it, it is necessary for the student to have more experience than he can get in one year's training, as introduced in the senior year. I do not think that it has a place in undergraduate work.

President Howe. I wholly believe that we need a vast amount of research work done in connection with our roads. We have only to look at the condition of roads which have been used for a short time by heavy trucks to see that we do not know how to build them. We have available over $800,000,000 to spend on roads, and we ought to conduct the most far-reaching researches before we put our money into anything which we do not know will be valuable or lasting. I think that any research carried on by students is absolutely worthless. I speak after watching research for 40 years in college. It is a valuable thing, as a rule, for the student to find how to conduct researches, but it is worthless to any one else. They learn mainly the methods of research, and they will become valuable research workers later on. With the tremendous amount of money to be spent and with the tremendous amount of traffic going over the roads, I believe the highway problems of so great importance to the country that we ought to have the very highest type of professional research work done, and not depend upon students except for the smallest and minor problems. Students can assist in these. Many of these researches must last more than a year. An undergraduate is available for only one year, and he can give only limited time in that one year, and after the senior year he is not available at all. Many of the problems should continue over many years before we can come to any correct solution in regard to them. If we were conducting researches in regard to anything in connection with commercial problems, we would not take an inexperienced boy and let him conduct the research work. We would take the very best man we could find and pay him whatever was necessary. Now, it seems to me that a large amount of money ought to be available for professional research work on the roads. Use graduates and undergraduates as much as we can for small things, but consider it a small part of the problem.

Mr. Goldbeck. I should like to second what Mr. Howe has said. The actual value of the research work turned out by the student can not be considered very highly. However, the training will be of value to him later. That is the most valuable thing.

President Howe. Surely that is the most valuable thing. Train them so they will be valuable later on.

Dr. Zook. This field is more or less foreign to me, of course, but I think that most engineers are agreed that they will not endeavor to specialize too much in any one direction. That means that they are not even going to endeavor to do very much research work in the junior and senior years. If any research work is done along this line, it will be done by graduate students. Can we get any kind of a statement from the persons qualified to speak here as to the necessity of graduate research in highway engineering problems,

and anything like the extent to which it ought to be prosecuted in our colleges and universities? That seems to me to be the problem.

CHAIRMAN. The discussion has centered upon two aspects of the case: One, the education of the undergraduate student. There seems to be an opinion that minor research as an educational procedure in the senior year is recommended as a part of the education of the student with the understanding that the products of that research are of no value in the matter of solving our big problems. Two, the importance of this subject is so great that fundamental research manned in the most thorough manner and financed so as to solve the big problems is necessary before we go very far in our road-building program. These two points seem to be perfectly clear from the discussion.

President HOWE. May I give an illustration? We started in Cleveland two years ago to pave our most important highway, Euclid Avenue. We used the best highway engineering and the best knowledge we had; gave it to a very competent engineer. In less than a year's time, I think in less than six months' time, in the very best section, a little over a mile in length, there were at least 50 holes in the pavement, if not more. I think that is what I mean when I say that we do not understand the methods to be used in the fundamental problems. In order to put down a good pavement we must consider the effect of water upon it, the effect of drainage upon it, the question of soil, the foundation necessary for the different kinds of traffic, the surface material which should be used, and the method of maintaining that surface. If the surface goes to pieces in a short time we should know how to replace that surface. We should have engineers who understand resurfacing.

Mr. HEWES. I wish to indorse what President Howe has said, as seconded by Mr. Goldbeck. I feel that research can not successfully be carried out by undergraduates, but in defense of the engineers in connection with what President Howe has just said I think it ought to be brought out at this conference that there is a fundamental lack of coordination between the construction of the roads and the operation of the rolling stock on the roads. Now, in the case of the railroads the same jurisdiction obtains over the construction as that which obtains over the design of the rolling stock, and the engineer knows, when he puts down a 40-pound rail, that he is not going to put over it the heaviest trains and locomotives. Now, what seems to be the fault of the highway engineer here is beyond his control in many cases. If the highway engineer can not have the guaranty of the traffic of the road that he is going to design, and can not be accorded sufficient funds to put down a road which will anticipate a 100 or 200 per cent increase in the duty of that road, we can not charge him with the failure of that design which is imposed on him by [illegible] of the

limitation of control and lack of money. So it seems to me that right there develops a very fundamental problem for research, so it may be somewhat of an economic or legislative problem rather than a problem of design. What seems to be the articulation between the investment and the cost and weight and speed of the rolling stock? That question leads us on indefinitely. For example, as to the relative effect of road on the vehicle—we talk of the destruction of the road by the vehicle, but have not said much about the destruction of the vehicle by the road. We have 7,500,000 vehicles which are being junked at an appalling rate. That is to say, the life of a vehicle may be seven years. With that rate in railroads they would be bankrupt in no time. How much money can we afford to add to what we have been spending for roads to cut down the depreciation of rolling stock? These are problems that it seems to me demand the very highest type of training. I think it is clear that undergraduates can not be intrusted with that. We must have great sums of money in the light of highways and rolling stocks involved. So that I suggest that we take up the question as to what authority is to propose these problems, as to what authority is given to a question when it is proposed, as to what grade of man can be intrusted with the solution of that problem, and how it shall be financed.

CHAIRMAN. Are we agreed as to the statement of the two aspects of research in relation to our committee? That is, educational and fundamental research.

Mr. CHAPIN. Is not there a question there? I am interested in graduate research. If it is carried on long enough, it assumes a value that is quite worth while. That is, a graduate engineer spends only six months or a year in research work. This makes for development rather than for training. Yet if it is possible to carry on research work in a subject as important as this over a period of time, say three years, the schools and colleges will supplement what is done by the Bureau of Public Roads and the various State highway departments. It would seem to be that there is a value in graduate research work which is surely worth while.

CHAIRMAN. I think that the discussion here refers to graduate research work and not to the work in the graduate schools. That is a different proposition, and I was just about to raise the same question as to whether it would not be advisable to recommend investigation of research work by competent investigators, such as in the National Research Council, where committees in charge have developed research work in chemistry and physics by scholarships to especially qualified men, with a five-year program and $100,000. It may run anywhere from one to five years. Does the committee wish to recommend that attention be called to that opportunity? Now, physics and chemistry both relate to this road work so closely

that some of those scholarships may be secured for research work in connection with our problem.

President HOWE. Are resolutions desirable?

Dr. ZOOK. It is desirable that the educational force of this committee should assemble and attempt to make some recommendations to the general body of what is indorsed here.

CHAIRMAN. Then I think any suggestions would be welcome to the committee.

President HOWE. I have prepared four resolutions which I believe state what the members said: (1) That highway research is necessary if we are to carry the traffic which must pass over the roads in the future. (2) This research should be under some central authority, such as the National Research Council. (3) That sufficient funds should be provided and placed in charge of this central authority. (4) That this central authority should use the State highway departments, professional State engineers, graduate research departments of our universities, and all other means which could be used to further the ends desired. I should like to suggest that for discussion, Mr. Chairman.

Mr. CHAPIN. Everyone would agree with you in that resolution. Did you include the industries? Several industries have research laboratories. It would be well to include them so as to coordinate all of them if possible.

Mr. GOLDBECK. Research work should be given to students for the purpose of training. It seems to me we are getting a little bit away from our functions here. We should deal primarily with matters pertaining to education.

CHAIRMAN. I think our committee has two functions, first, educational research; and second, fundamental research. As it was stated, it is desirable to call attention to the necessity for fundamental research. I do not think that President Howe intended to leave out the educational phase, or the importance of training students along lines of research that in future they may become efficient research engineers.

President HOWE. No; I should be very glad to put that in. Universities and colleges should train their students as far as possible in research so that in the future they will become efficient engineers.

CHAIRMAN. The next topic is very similar to that: The consideration of technical research in automotive industries.

Mr. DAVIS. The Society of American Engineers has recently formed a committee, of which I am a member, for actually looking into what we call the science of truck operation. It is an attempt to formulate certain underlying economic principles bearing on the construction of road transportation in comparison with the railways, waterways, and horse transportation, and in that way to develop

certain material, collect statistics, and to make available for our use, not only in the small endeavor that we have undertaken in our plants, but also more or less to give out to these technical schools and colleges who are going into this subject of highway engineering. Now, so much for the actual acquiring of that information. The information at the present time is more or less scattered. It is in the hands of a few, but the Society of American Engineers and the manufacturers will be very willing not only to lend their time and their best efforts to collecting and tabulating this information, but when it is available and when the courses are mapped out in the colleges, men from the companies and from the society, I know, will be very glad to volunteer, certainly at the start, and possibly for more or less continuation, in order to go before these schools and before these various technical colleges and present that material. That is, they will be willing to volunteer to more or less degree to conduct some of the courses in transport engineering, due to the fact not that instructors are not able to handle it, but because the information is so vague and scattered that it is not available for the college instructor to secure himself. The Society of American Engineers is going to take the material which is collected and boil it down, and then print in some form or another and make it available for anyone who may want it.

Dr. JARVIS. It will serve as a nucleus.

Mr. DAVIS. The highway end is much better off than the transport end. With the exception of the foundation to support highway trucks, the other phases are very well understood, but the transport end of it is particularly shy of this information. Now, if there are any other suggestions here or any other scheme whereby the Society of American Engineers can get at that information so as to cover the ground, we would like very much to get that at this time.

CHAIRMAN. Has anyone a suggestion to make?

Mr. JOHNSON. What does the word "research" mean?

Mr. DAVIS. I really don't quite understand what the meaning is of that statement. Do you mean technical research in the design of the building of the vehicle or in the building of the road? I hardly understand what is meant by technical research in the automotive industries.

Mr. CHAPIN. Might I suggest that the most profitable research that can be carried on is what I outlined this morning; that is, how traffic over the highways can be made to go at the least possible cost per mile, be it per ton-mile or per passenger (traffic) mile. It is the research in the economics of the situation.

Mr. DAVIS. That is one of the phases that the Society of American Engineers committee will consider. That is, as I see it, only one phase of what the word "research" covers in regard to the auto-

motive industries. Research in an industry covers materials, fuels, etc. Your question is very good and a very important side of it, which we know very little about at the present time.

CHAIRMAN. I do not think that we should exclude questions in regard to design and those which are of more importance fundamentally, because the colleges and the Research Council want to know whether you have research problems there that you want institutions to attack; and if so, what they are.

Mr. DAVIS. We have lots of problems that we are attacking ourselves in a research way, but it is almost impossible to outline what those requirements are in a broad sense.

CHAIRMAN. You think that the competent research men in those fields would perhaps know the problems?

Mr. DAVIS. I think they are very well qualified to conduct that research.

CHAIRMAN. Does anyone have any suggestions along that line?

Dr. ZOOK. I wonder if it would not be a good idea to see in what field of research we need study at the present time.

Mr. DAVIS. Mr. Chapin has named the one phase which has had the least consideration.

Mr. CHAPIN. I am looking at this problem from the standpoint of transportation. As to the problems of design of car, fuel, etc., they have received a great deal of consideration, and much money and brain work are being devoted daily, but little so far has been developed as to the cost of that transportation over the highways, and in my own mind I am trying to compare the problem with the railway problem, which is the maintenance of the way and maintenance of the stock over that way. But we have discussed the research problem in so far as it concerns highway building, but there has been very little time and energy put in the question as to cost of transportation over the roads, and it is such a general subject, and bears intimately in its economic phase on everybody in the country. It pertains to the cost of living, and it is a subject for general research on the part of the people outside the automotive industry, although the automotive industry would be glad to get research of other questions as to fuel, etc. Here is a problem that is entirely new.

CHAIRMAN. I presume you know that in the matter of this fundamental research, not in economic lines, but in fundamental research lines, the National Research Council is always glad to learn of any problems and give any assistance it can in those fields. If there is no further discussion of this phase of the subject, we have for discussion the question of business education, to be opened by Dr. Zook.

Dr. ZOOK. I think this subject in its very nature is much more general than either one of the two that we have so far considered.

It is a problem which can be solved, not only in colleges and universities, but to a certain extent in other schools. It is also a problem which can be solved in various places in the colleges and universities.

A good deal more can be done than is being done at the present time to teach pupils in the elementary schools something of the elementary forms of business, not only for the benefit of industry but also for the benefit of the individuals concerned. In the secondary schools also there is a great deal of room for expansion, and we find in large cities there is an attempt to perform that function through the business courses in high schools. Undoubtedly in the elementary grades and in the high schools, as well as in the colleges and universities, there is an appreciation that these problems need solution.

Now, when we come to the colleges and universities, in which we are all more concerned, there are to my mind three different places where an attempt may be made to give a business education. The problem may properly be considered in connection with the engineering schools; it may properly be considered in the courses in commerce and finance that are now increasing in number in colleges and universities; and it may be considered also in connection with the usual courses in arts and sciences. I would like to say just a few words in connection with each of these three classifications.

1. The engineers present will remember that it has not been very long since an engineering student was trained as a technical student primarily. In recent years a great many engineering schools have been incorporating in their courses a certain amount of economics. The tendency a few years ago was to include one course in general economics. That one course in general economics is even now more usual than anything else. I can testify through several years of personal experience that that one course taught to engineers has been somewhat of a disappointment. It has been a disappointment because the technical students do not feel that they get out of it what they ought to have. It has been a disappointment also, because the character of the instruction given was not of the grade that it ought to be. I am very fond of saying that there is no person who ought to be more highly trained than the person who deals with the social sciences. He ought to be the ablest man in a college faculty, almost without exception. Immature young men when teaching courses in general economics in engineering schools have not always been successful, and our technical students are unprepared to meet the problems of citizenship that they are required to meet as soon as they graduate.

We have had recently a movement in engineering schools to supplement the course in general economics with courses in business economics, and it is now becoming somewhat usual for engineering

schools to devote from 6 to 12 hours of their work to courses in general economics and business economics. These are courses that have to do with business management, corporation law, finance, business law, transportation problems, and with a number of other problems. I believe that the student who has taken courses of this character is going to be an extremely useful man in the automobile industry or any other large industry. I think there is nothing that engineering faculties are more agreed upon than that students need more or less of this training. If engineers can receive training of that sort they will take the places for managers and directors in corporations that are needing men of that character at the present time.

2. College and university courses devoted chiefly to business and finance. I do not know of any field in which the number of students is increasing at a faster rate than in business courses. Institutions that are not even well located for this type of work have only to advertise that they intend to give work of that character in order to obtain a large registration. In that respect, therefore, I think one may say that the supply of students that will be turned out by colleges or universities will be increased very materially indeed. I don't know whether this is much comfort to industrial people, but it ought to be if the training is of the value it should be.

3. There remains, therefore, only the third character of students, namely, the liberal arts students. At the present time there are on the average about 14,000 graduates per year from these courses. The time was that a large proportion of these students went into teaching. To the very great detriment of the teaching profession at the present time they are not going into that field, and we were forced to estimate at the Bureau of Education a short time ago that instead of one-half to two-thirds going into teaching, perhaps not more than one-third are now going into that field, and most of these are young women. It appears to me that an increased proportion of graduates from the arts and sciences courses are going into the business world. A larger opportunity ought, therefore, to be given students in arts and sciences to pursue a certain amount of work which will fit them for taking positions in industrial corporations. and I may say everywhere I find an increased tendency in that direction. If you had any experience in attempting to get teachers in colleges and universities you will bear me out when I say that there is no field in which it is more difficult to obtain competent teachers than it is in connection with these courses in business and business economics. That shows what the tendency is.

There are these three fields in colleges and universities for courses in business economics, therefore, and to my mind there is in each one of them an increasing tendency to prepare students who are fitted to take over positions of managers of corporations, after train-

ing in the corporation itself for some time. The prospect in all these fields is encouraging. I believe that most heads of corporations will agree that it is unnecessary for all men in managerial position to be technically trained.

One other thought I should like to leave: There is naturally a tendency on the part of everybody to feel that those courses in business economics which I have just mentioned should be as practical as possible. I think that it is highly to the interest of the industries to realize that not only do they need men who are trained in business economics, but that along with this work there should be a generous training in the social sciences, which are not supposed to be so practical. I am thinking of courses in political science, where men learn something of city government, State government, and of the politics of our country, together with a certain amount of modern history. I say this because I do not understand how anybody can be a leader in a corporation or in any other circle of society who is nothing but a technical man. Not only for the benefit that comes to the student as a citizen, therefore, but as a practical avenue to business success it is highly desirable to mix with the business economics courses a generous portion of these other courses.

I do not know whether I have outlined satisfactorily the three fields for courses in business education in colleges and universities, but I think that in this direction there is greater hope that the demands of industry will be met by the colleges and universities than in almost any other field.

CHAIRMAN. Are there any comments on this?

President HOWE. I am much interested in what Dr. Zook has said, because it is our experience, and presumably it is the experience of other institutions, that a very large proportion of our graduates who have been out for 15 or 20 years, and who are now presidents, vice presidents, or managers of large organizations, come to me and tell me how they have felt when they first had to deal with business problems. Some of them were scared to death when they had to sit across from a girl stenographer. I have tried to help these men a little by having some courses of lectures given to seniors. I tell them that I hope after graduation they will take special courses at Alexander Hamilton Institute, but I find that after seniors have had this very brief course of lectures they come to me and say, "Can we get into the business section instead of the technical side?" We encourage a few of them to do it, because we think they ought to do especially well in executive positions. Dr. Zook's statement meets very well with my own experience.

Mr. HEWES. I should also like to support what Dr. Zook has said of the failure of engineering training to sufficiently equip the man along the lines he has indicated. For example, the question arises,

how can we coordinate the expenditure of the public funds with the amount which can be used in the construction of roads. This depends upon the knowledge of how much roads can be made to earn. The student should be given sufficient instruction and vision along the lines of taxation and finance, interest and bond issues, so that when he goes to make a report on a system of roads he may not merely report on materials, on their location, and also on the period of time that it will be necessary to construct this system, but he may be able to justify his report by the necessary sustaining data. I do not think technical graduates are equipped along these lines, and I want to express myself in support of what Dr. Zook has said. The course is now crowded, and physicists and geologists are both claiming more time. But we must bear in mind that we must make room for all who should come in in four years.

Mr. HEMINWAY. I am quite in sympathy with the comments which have been made by Dr. Zook. I feel that there should be a closer contact established between our industrial leaders and our educators. From my observation of men, if they come from colleges equipped theoretically to assume managerial positions, they have very markedly lacked the practical element. They have been unable to apply their theories for quite a considerable period of time, and, as has been expressed, they have found themselves lost in the first element of dictation. Coincident with the studies in the colleges and in the secondary schools there should be an opportunity offered, possibly during the summer months, for practical application of those studies and those theories in business, and if a canvass were made of our large industrial leaders I think that an interest might be aroused whereby students might have courses in factories and offices. The industrial management is a little disinclined generally to accept that thought for the reason that it is expensive; it increases essentially the general routine work. In general, however, I think a great many of them are sufficiently broadminded to accept it.

Mr. CORLEIGH. I was a little bit alarmed when I thought you told Mr. Davis we were not concerned with the vocational element. I am so full of that subject that I can hardly talk on anything else. I think that there is a great deal to be said of the maintenance end of the automotive industry. We are going to need more and more technically trained men to take executive positions in repair work, as well as design and production. We have thus far followed the program of promoting the better mechanics to the executive positions. But I believe that the time is coming when the maintenance work will be carried out on such a scientific plan that it will need technically trained men to do it. It will become worth the while of a full-sized engineer to plan out ways and methods, systems and organizations, and all those other things which are so much involved

in production, in repair methods. If these methods were followed in the factory we would make automobiles cost four times as much as they do. By applying the same theory in the repair of cars we could repair them for about one-fourth of what we do now. Now, that may be an unattainable ideal, but I believe that when business sense and engineering genius are applied to the maintenance problem we will be able to conduct this work in a very efficient way.

Mr. LOGAN. I think that if we had here a number of the executives of the industry with which I am connected they would want to give Dr. Zook a vote of thanks. As an evidence of how much it means to take an engineer along the lines of business, I think everyone will agree, when a young man or even an old man comes into an engineering organization, if he is in a position to understand his work not only from the engineering end but from the business end, there is a cooperation that works to the advantage of the company which he represents. But if he only works from an engineering point of view, the man in the office with only the business view does not get along with him. The result is, if we will put more in the course relative to the business, when he does come into an organization he will see that there are other problems from the commercial point of view. I have in mind a technical man in our office to-day whom I believe would rather be in the commercial end, because he is always cooperating. He is always doing everything he can, not only from the engineering standpoint, but from the other end of the business. I recall about five years ago, when I was with another organization, a man who had not the sense of cooperation, but was strictly a technical man, was called into a conference. He could "gum up" more business for me than I could 'rake up" in a year's time, because he saw it only from the engineering point of view. On the other hand, the other man is right there on the spot to cooperate, and will see our line of thought. The engineer who has not had business training has only one thought, and that is engineering.

Mr. DAVIS. I would like to bring out possibly another point in connection with that. I have had charge of a number of draftsmen in the engineering work, and many times young engineers right out of college will come to me and ask if I would advise them to go into the commercial end, or in the administration end, or into the strictly engineering line of work not connected with the automotive industries. I have answered them in this way: First, I ask them what they studied in addition to technical work. If they have taken courses in economics and business administration, that is fortunate. Beyond that I ask them if they absolutely can not help but go into engineering. If they are not ordained to be engineers, they had better go into the business end, into the sales, commercial, or one of the other ends. The demand for the highly trained technical engi-

neer who succeeds is not great in the automotive industry. The demand for men with an engineering training who know the other phases is very great indeed, and I can not put too much emphasis on the fact that the engineers should have an insight into the economic side, because when they come out of the engineering school only a very small percentage are fitted to continue in the engineering work, strictly speaking. The others will be forced out of the engineering, and if they can have a little training before they start to work which will give them certain principles of business training, they are 100 per cent better off than the man who has gained it by actual experience.

Dr. JARVIS. I have nothing to contribute to this discussion except to note that we have overlooked one important phase. President Howe says that our four-year course is too overloaded, and has too much in it. That has suggested to me that we need a little closer articulation between the secondary and higher institutions. Is it not possible to crowd back into the high school some of the work we are now offering in the colleges? Many boys in high school know they are going into engineering. That is the case to-day more than previously. Some men have looked to an industrial career, and why should we not have a greater flexibility in our secondary school course, and provide for general industrial curricula in the high schools? It seems to me that that would give us more time in higher institutions to give instruction in business economics and managerial instruction. President Brush, of the Emergency Fleet Corporation of Philadelphia, said that hardly a graduate of a technical school knew what a balance sheet looked like, or knew the difference between a lease and an invoice. We can give more in our secondary school courses, also along the lines of business training, to make up for the deficiencies that we realize now in our engineering graduates. If they had some instruction in business forms and business methods there would not be the need for them in the college course. At the same time our college course must make sure that the graduates have that training along economic business lines before they go out. We should carefully articulate the secondary courses with those of the colleges and universities.

MEMORANDUM REGARDING RESEARCH WORK TO BE UNDERTAKEN IN HIGHWAY ENGINEERING.

By Mr. A. T. GOLDBECK, Engineer of Tests, Bureau of Public Roads.

There are many problems to be undertaken in connection with the design and construction of highways. The advent of the heavy motor truck has brought with it problems in construction and design which

hitherto have needed but very little consideration. The roads which we have built in the past were built with the idea of carrying comparatively light, fast-moving motor traffic, and they were generally quite satisfactory for this purpose, but they have become entirely inadequate for the extremely heavy loads imposed on them by the more recent heavy motor-truck traffic.

There are numerous problems which have to do with the alignment and grades of roads, curve elimination, banking of roads on curves, maximum grades, character of materials for wearing surface, but by far the most important problem is that of the determination of proper designs to carry successfully heavy traffic.

The design of the present day road surfacing is an exceedingly complex problem. In the first place, the loads acting on the road surface are not merely static loads but they are applied with considerable impact. The road surfacing does not rest on a uniform support, but this support is extremely nonuniform in character, varies from day to day, and even varies according to the character and position of the load on the road surface. The analysis of stresses in road slabs is, therefore, a very complex problem in applied mechanics. At the present time this problem is being attacked by the Bureau of Public Roads in the following general way.

In the first place, since the loads are applied with impact due to the unevenness of the surface and speed of the moving vehicles, an attempt is being made to determine accurately the amount of this impact. Different sizes of trucks are being used, and pneumatic as well as solid tires are being investigated. As in the design of any structure, after knowing the amount of load imposed on the structure, the next step is to determine the effect of that load, and for this purpose another series of tests is being carried out in which a large impact machine designed to resemble the conditions on the rear wheel of a heavy truck is being used. This machine exerts impact on road slabs of different construction laid directly on the subgrade, and the effect of continuous impact on these slabs is carefully noted. Still a third investigation is being carried out in which a specially designed machine is rolled over the sections of pavement in order to produce accelerated wear on these sections, and careful photographic records of the behavior of these sections under accelerated traffic are kept.

As the subgrade is part of the road structure, a comprehensive series of investigations has likewise been started to study the characteristics of the soils which make good or poor supports for road surfaces. In addition, studies are being made of methods of drainage in an attempt to develop effective systems as applied to different conditions of soil and topography.

These are some of the big main problems in structural design of roads, and these major problems are capable of subdivision into a

large number of minor problems, some of which appear in the following list:

THE SUBGRADE.

(a) *Properties of the Material Composing the Subgrade.*

1. The bearing power of soils subjected to various compressions and containing various amounts of moisture.
2. Study of capillarity, both vertical and horizontal.
3. Effect of mechanical analysis and chemical properties on capillarity.
4. Interrelation of type of soil, percentage of moisture and volume.
5. Effect of freezing and thawing on volume and supporting properties of soil.
6. Study of the distribution of pressures through soils due to concentrated loads.
7. Study of methods for improving bearing power of soils.
8. Methods of compaction and amount of compaction to be given to subgrades to render their volume constant.
9. A study of the friction between subgrades and road surfaces.

(b) *Drainage of the Subgrade.*

1. Study of the drainage methods to be applied to soils of different types.
2. Study of methods of rendering soils impervious.
3. Study of drainage to take care of freezing conditions.
4. Study of conditions affecting run-off.
5. Study of gutter design under different conditions of grades and soils.
6. Study of inlets.
7. Study of embankment wash as affected by roadside planting.
8. Study of percentage of moisture in various subgrades at various depths.
9. Study of various methods of drainage to be employed with various types of subgrade.
10. Study of heaving of road slabs due to frost.
11. General study of the relations existing between the physical properties of the soil composing the subgrade and behavior of the road slab might include a comparative study of subgrades which show typically good and poor bearing power in various seasons of the year and under both good and poor drainage conditions.

THE WEARING SURFACE.

In the wearing surface there will be included the road foundation as well as the actual surface material subjected to the action of traffic. A study of the wearing surface involves an investigation of the forces which act upon the surface tending to destroy it, a study of the properties of materials employed in the construction of the surface, their proper combination, and the design of the pavement as to thickness and shape of cross section. Each type of wearing surface possesses defects which render necessary investigations to improve these particular shortcomings.

AMOUNT OF IMPACT ON ROAD SURFACES.

The measurement of impact on roads, using trucks of different weights, tire equipment, and wheel equipment, should be made.

EFFECT OF IMPACT ON ROAD SURFACES.

The effect of the impact of trucks on various combinations of road surfaces should also be investigated. The following surfaces are suggested for investigation:

Plain concrete.

2, 4, 6, 8, or 10 inches by 7 feet square; also 6 inches thick by 14 feet square.....Poor subgrade.
Do.....Well-drained subgrade.

Monolithic construction—Wire-cut lug brick.

1-inch screenings.....Good subgrade.
1, 2, 4, or 6 inch concrete.....Poor subgrade.
Do.....Well-drained subgrade.

Monolithic construction—Vertical-fiber brick.

4 or 6 inch concrete base.....Good subgrade.

Monolithic construction—Repressed brick.

4 or 6 inch concrete base.....Good subgrade.

Semimonolithic construction—Wire-cut lug brick.

4 or 6 inch concrete base.....Poor subgrade.
Do.....Well-drained subgrade.

Sand-cushion construction—Wire-cut lug brick.

4 or 6 inch concrete base.....Poor subgrade.
Do.....Well-drained subgrade.
4 or 6 inch concrete base, using 1-inch screenings.....Well-drained subgrade.

Wire-cut lug brick—Grout filler.

6 or 12 inch macadam foundation.....Poor subgrade.
Do.....Well-drained subgrade.

Vertical-fiber brick—Bituminous filler.

4 or 6 inch concrete base, sand-cement cushion.....Poor subgrade.
6-inch concrete base, sand-cement cushion.....Well-drained subgrade.

Vertical-fiber brick—Bituminous filler.

4 or 6 inch concrete base, sand cushion.....Poor subgrade.
6-inch concrete base, sand cushion.....Well-drained subgrade.
4 or 6 inch concrete base, screenings.....Well-drained subgrade.

Wire-cut lug—Bituminous mastic cushion and filler.

4 or 6 inches.....Poor subgrade.
6 inches.....Well-drained subgrade.

Monolithic construction—Three-inch wire-cut lug brick.

3 or 4 inch concrete base.....Poor subgrade.
Do.....Well-drained subgrade.
4 or 6 inch bituminous base, 4 inches brick.
Mastic cushion and mastic filler.
Cold mix base.
Rich concrete base for brick slabs.
Concrete slabs having poor aggregate.
Concrete slabs 6 inches and 8 inches thick, plain and reinforced.
Bituminous surfaces on concrete and other bases.
Reinforced concrete slabs of different thickness.

The above tests have to do with the load-resisting qualities of the pavements. Special types of pavement should be investigated through special investigations, as follows:

CONCRETE PAVEMENTS.

1. A study of the economical proportions for various aggregates to render the pavement resistant to abrasion. (For instance, the economy of 1:2:3½ vs. 1:2:4 mixture.)
2. A study of the wear-resisting qualities of concrete, using special aggregates such as soft limestone, soft sandstone, blast furnace slag, etc., as compared with standard aggregates such as gravel, trap rock, etc.
3. A study of admixtures such as hydrated lime and diatomaceous earth.
4. A study of central-plant-mixed concrete versus concrete mixed at the work.
5. The effect of consistency.
6. A study of the size of aggregates on the physical properties such as resistance to abrasion and crushing strength.
7. Vibrolithic concrete.
8. Machine finished versus hand finished concrete roads.
9. A study of the cracking of concrete surfaces.
10. The prevention of the creeping of surface on grades.
11. Prevention of heaving and slab over-riding.

REINFORCED CONCRETE PAVEMENTS.

1. Per cent of steel required to prevent serious cracking under different subgrade conditions,
   (*a*) Under impact,
   (*b*) Due to other causes such as freezing, temperature change, and moisture change.
2. Proper location of steel.
3. Circumferential steel.
4. The use of hard or soft steel, rerolled rail, or billet steel.
5. Plain or deformed bars, the use of bars or sheet steel.
6. An investigation of the use of steel tracks.

BRICK PAVEMENTS.

1. What thickness is comparable with concrete and other types on various subgrades.
2. How do various types of brick construction compare in strength?
3. What rattler loss should be set for different traffic conditions?
4. Should individual brick losses be kept within a narrow limit? What is the average per cent of loss and adequate specification?
5. Study of abrasion resistance of brick having different rattler losses.
6. Study of the relative merits of Portland cement grout and bituminous fillers.
7. Study of relative merits of rattler and toughness test for paving brick.
8. Study of the merits of "lugless" brick.

BITUMINOUS CONCRETE PAVEMENTS.

1. The resistance to impact of bituminous pavements as compared with concrete and brick on basis of different kinds and thicknesses.
2. A study of the proper gradings of mineral aggregate for bituminous concretes to obtain maximum density and rigidity to eliminate waving and humping.
3. An investigation of the test requirements for different types of bituminous materials for use in various types of bituminous construction under different climatic conditions.
4. A study of the formation of waves in asphalt surfaces.
5. A study of the relative merits of concrete, bituminous concrete, or broken-stone bases for bituminous concrete or bituminous macadam pavements.
6. A study of bituminous earth mixtures, with the idea of developing an efficient surfacing for parts of the country where aggregates are not available.
7. The development of an efficient method for protecting concrete wearing surfaces with bituminous mats.
8. A study of special aggregates for bituminous concrete, such as gravel and blast furnace slag.

BITUMINOUS MACADAM.

1. Study of the characteristics of bituminous materials to be used with different types of aggregates in various parts of the country.
2. A study of the most efficient size and grading of aggregates for use in bituminous macadam.
3. A study of concrete versus broken-stone foundation for bituminous macadam.
4. A study of methods of repair for wavy bituminous macadam surfaces.

LABORATORY STUDIES.

NONBITUMINOUS MATERIALS.

1. Develop a suitable abrasion test for aggregates for use in concrete pavements.
2. Standardize the crushing strength test for rock, brick, etc.
3. Standardize an abrasion test for gravel for use in gravel and in gravel concrete roads.
4. Develop a test for stone paving block.

5. Investigate proper methods for sampling paving materials.
6. Standardize tests for silt in sand and gravel.
7. Develop methods for laboratory investigations of sand-clay for sand-clay roads.
8. Investigate blast furnace slag with the idea of formulating safe specifications for various types of construction.
9. Develop a satisfactory method for testing sands for different proportions of concrete, mortar and grout other than the strength ratio method.
10. Standardize the commercial sizes of broken stone, broken slag, and gravel.

BITUMINOUS MATERIALS.

1. Density of bituminous mixtures involving the temperature at which maximum compression is obtained.
2. Determination of water in bituminous road materials.
3. Determination of flash point of bituminous materials.
4. Comparative volatilization tests on asphalts and road oils in the New York Testing Laboratory gas oven and in the Frear electric oven, using 20 and 50 gram samples.
5. Adhesion of bituminous fillers to brick and stone blocks.
6. Toughness of bituminous aggregates.
7. Investigation of the chemical composition of bituminous materials for the percentages of asphaltous acids and their anhydrides, asphaltenes, petroleum resins, and unaltered petroleums before and after being subjected to exposure tests, with the idea of determining the change in the chemical composition that takes place.

PROBLEMS IN ECONOMICS OF ROAD CONSTRUCTION.

1. What effect have grades on cost of haul?
2. What effect have different surfaces on cost of haul?
3. What effect have curves on cost of haul?
4. What effect have different surfaces on the wear of tires?
5. How should motor vehicles be taxed?
6. Under what conditions should a road be improved to take care of increased weight of traffic.
7. Study and development of economical schemes for handling materials at the quarry, crushing and screening plants.
8. Study of the tractive resistance offered by various road surfaces.

The above problems are listed merely as suggestions of the amount of research work which should be undertaken. Undoubtedly there are numerous other problems which, in turn, are capable of being subdivided into minor researches, some of which could be carried out by engineering students under proper supervision.

The highway problem has developed into a complex problem of design and has become one of great importance, due to the vast expenditures of public funds for highway construction. Highway research should, therefore, be organized on a national basis, and every research laboratory in the country should be included in a national problem of highway research.

CURRICULA SUGGESTIONS IN BUSINESS EDUCATION.

I. *High schools.*—Bookkeeping; commercial law; elementary banking; and elementary practical economics.

II. *Colleges and universities.*—In this connection attention is called to the recommendations of the Conference Committee on Commercial Engineering, which met at Washington, D. C., March 31 and April 1, 1919:

1. That from 12 to 18 semester hours be required in all engineering courses in the following subjects: General economics; cost accounting; business reorganization; and business law.

2. That a curriculum providing for a minimum of 15 to 30 units in business economics be incorporated in all engineering courses and offered on an elective basis. It is recommended that electives be encouraged in connection with all engineering courses in the following subjects: Labor and employment problems; statistics; corporation management and finance; political science; marketing, including advertising and salesmanship; psychology; scientific management; and transportation. It is further recommended that economic phases of engineering subjects be emphasized wherever possible in engineering instruction.

In addition to the subjects suggested by the above conference committee, students should be permitted and encouraged to elect a course in highway transportation economics if possible.

Students in arts and sciences should also be permitted and encouraged to choose from 12 to 18 hours of work from among the foregoing subjects.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Chairman: Roy D. Chapin, president, Hudson Motor Car Co., and vice president of the National Automobile Chamber of Commerce.

Secretary: Pyke Johnson, secretary of highways committee, National Automobile Chamber of Commerce.

Whereas American science and industry have forged a new unit of highway transportation which is destined to bring about a far-reaching change in life and thought not only in this country but in the world; and

Whereas the problems of highway engineering and of highway transportation engineering are so closely interrelated as to demand not only the highest type of trained men to guide them but an appreciation of the entire problem of highway transportation by both highway and transportation engineers; and

Whereas the American people have seen fit to meet the needs of highway transportation with appropriations for hundreds of millions of dollars for better highways, which can only be expended efficiently and intelligently as we comprehend to the fullest extent the economic relationship existing between the roadbed and the motive unit; and

Whereas these problems, calling as they do for men of the highest collegiate and vocational preparation, can be solved only as our educational institutions

are able to meet this need with increased facilities for research, study, and practical application; Now therefore be it

Resolved, That we, the representatives of education, industry, and Government, assembled in national conference at Washington, D. C., at the call of the Commissioner of Education, to discuss this subject and to formulate recommendations concerning it, do hereby concur in the following statements:

That there is no one domestic activity of more vital import to the people of the United States than an efficient and economical administration of our highway program;

That there is a pressing demand for trained men, not alone to guide this program, but also to undertake the problem of production and the economic use of vehicles over the highway;

That this need can only be met by increased educational facilities for turning out these men;

That the entire subject is one which should be closely coordinated and a permanent committee made up as hereinafter designated should be appointed by the Commissioner of Education to consider this problem in its several aspects and to bring about a fuller understanding of it on the part of the people of the country.

That the component parts of this committee should represent the Bureau of Education, the Bureau of Public Roads, the War Department, the State highway departments, the automotive industries, the tire and rubber industries, higher educational institutions as the groups best equipped to furnish the technical information needed and to work out these great public questions.

ROY D. CHAPIN,
H. S. FIRESTONE,
PAUL D. SARGENT,
THOS. H. MACDONALD,
CHARLES S. HOWE,
Resolutions Committee.

THE PERMANENT COMMITTEE.

In harmony with the foregoing resolutions the following committee on highway and highway transport education was named:

P. P. Claxton, Commissioner of Education, chairman.

Thos. H. MacDonald, Chief of the Bureau of Public Roads.

Paul D. Sargent, chief highway engineer of Maine, and president American Association of State Highway Officials.

Col. Mason M. Patrick, Corps of Engineers, United States Army, War Department.

Roy D. Chapin, vice president National Automobile Chamber of Commerce.

H. S. Firestone, president Firestone Tire & Rubber Co., representing the Rubber Association of America.

F. L. Bishop, dean of the School of Engineering, University of Pittsburgh, and secretary of the Society for the Promotion of Engineering Education.

At a recent meeting of the permanent committee on highway and highway transport education, Prof. C. J. Tilden, S. B., M. A., professor of engineering mechanics at Yale University, was elected to direct the educational program of the committee, the trustees of Yale University having consented to release Prof. Tilden until September 23, 1921.

INDEX.